Halma Water Management

DigiCall
Correlator training guide

September 2009

A HALMA COMPANY

Contents

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Background to Leak Noise

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Noise Sources

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- **Leakage**
- **Partial obstruction of pipe bore (foreign object)**
- **Consumption**
- **Pressure reducing valves (PRV's)**
- **Partially closed valves (throttled or passing)**
- **Close proximity of main to sewer/culvert pipe**
- **Changes in pipe diameter**
- **Water pumping**
- **Electrical interference**
- **Pipe lining**

Leak Noise Quality

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- **Important Factors**
  - **Clarity**
  - **Strength**
- **Good Leak Noise**
  - **Clear, light & easy to distinguish**
  - **Strong & easy to hear**
- **Poor Leak Noise**
  - **Dull, muffled & difficult to distinguish**
  - **Weak & difficult to hear**

Vibration and Pressure Wave

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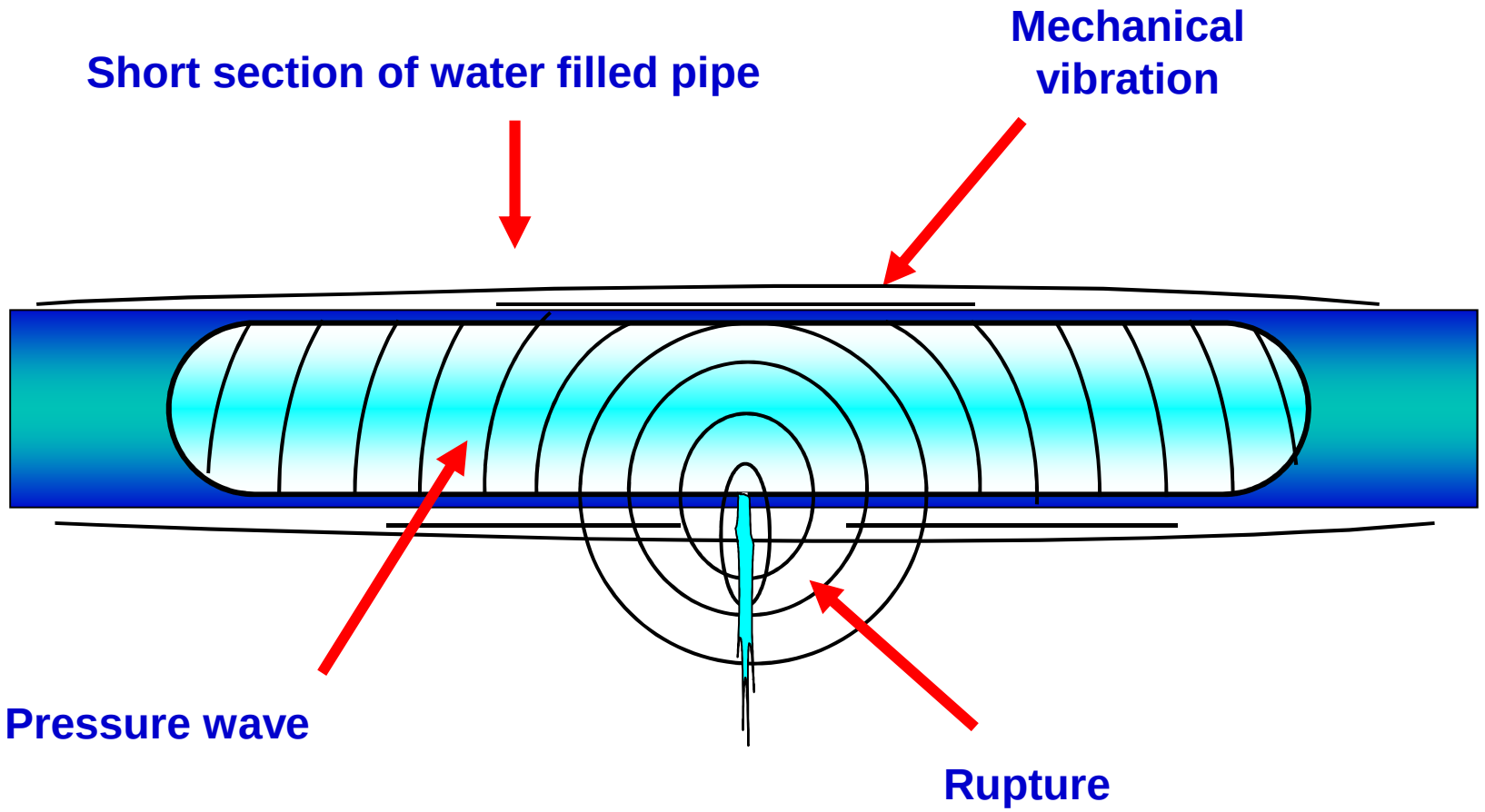

Hard Backfill Diagram

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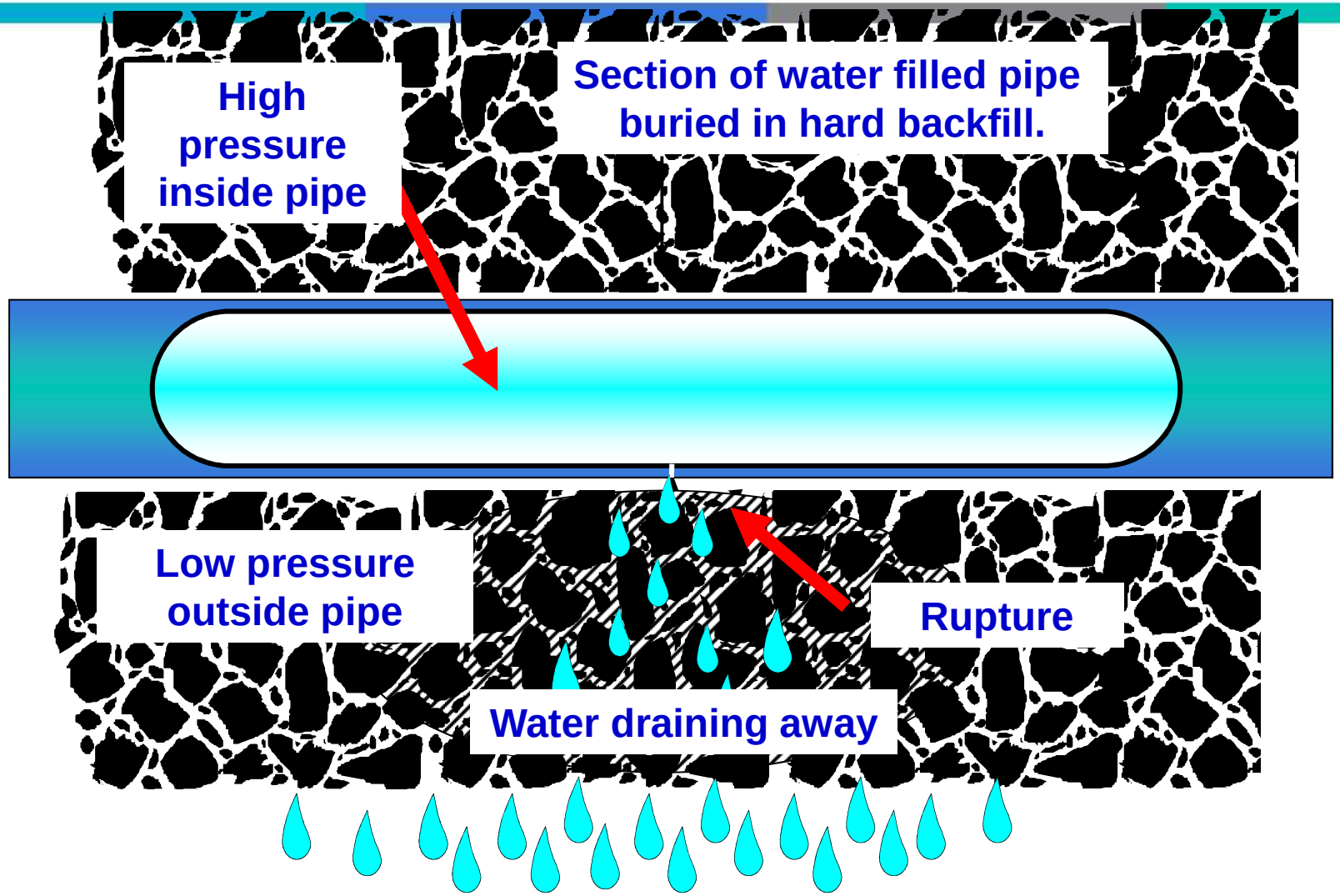

Soft Backfill Diagram

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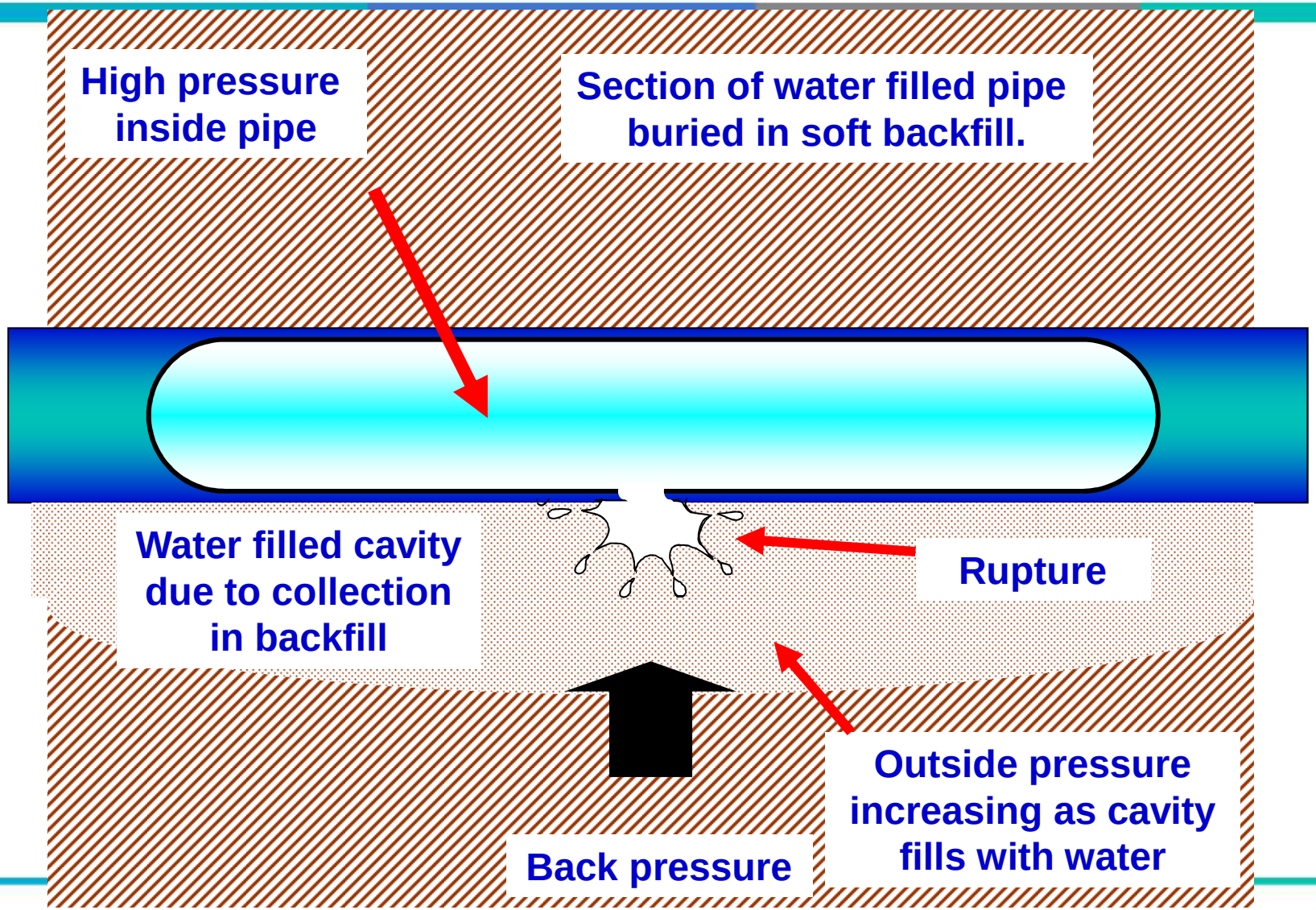

Complete Rupture Diagram

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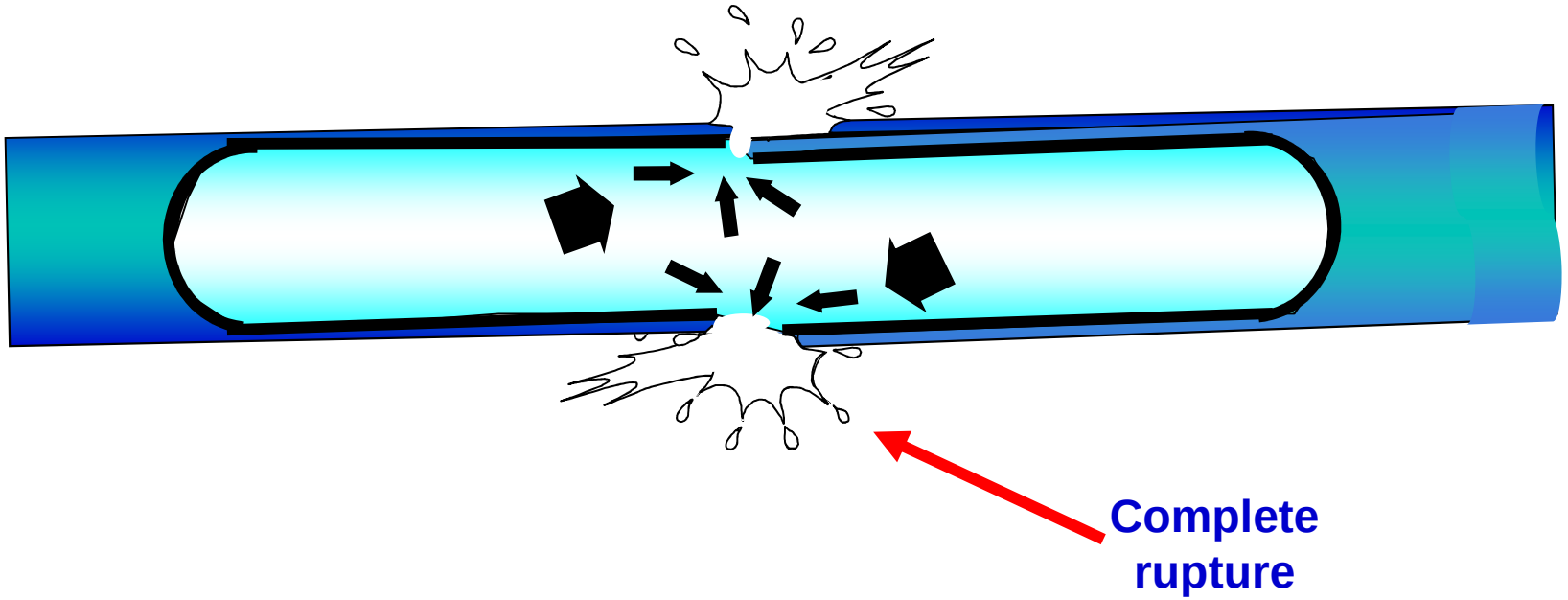
Pressure within pipe is lost



Small Rupture Diagram

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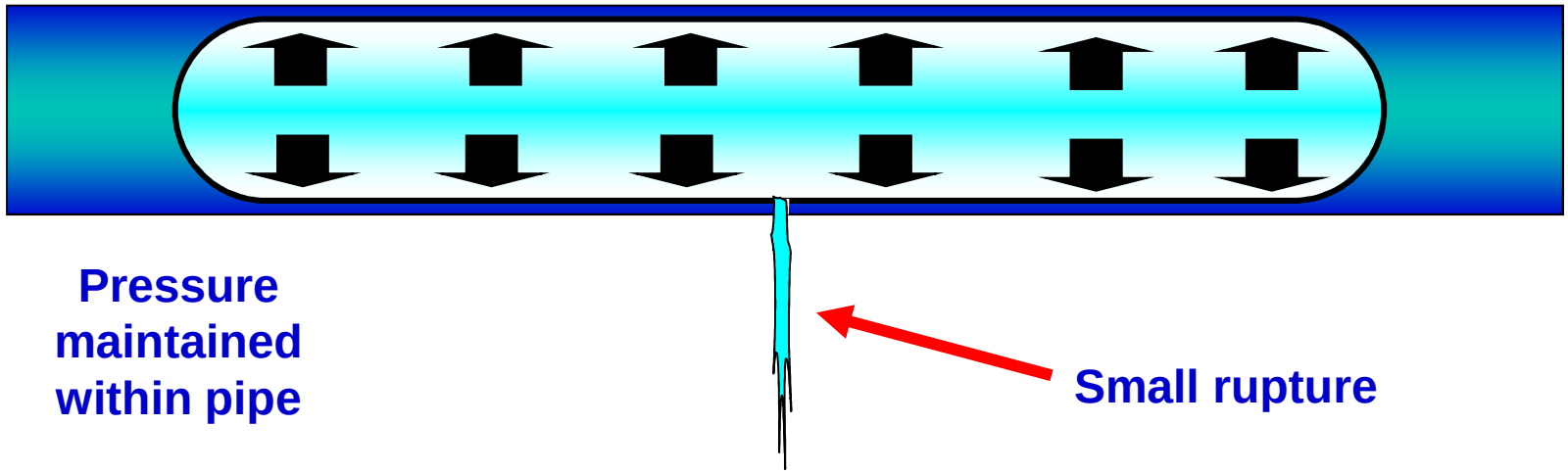

Material Types

- **Steel**
- **Iron**
- **Copper**
- **Asbestos Cement**
- **Lead**
- **PVC**
- **Polyethylene**

- **Hardest**

- **Softest**

Leak Noise Factors

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Factors producing good quality leak noise	*Factors producing poor quality leak noise*
High water pressure	**Low water pressure**
Hard backfill	**Soft backfill**
Small rupture	**Split mains**
Clean pipes	**Encrusted pipes**
Metallic pipes	**Soft/Lined pipes**
Small diameter pipes	**Large diameter pipes**

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Correlator Terminology & Principles

Correlation

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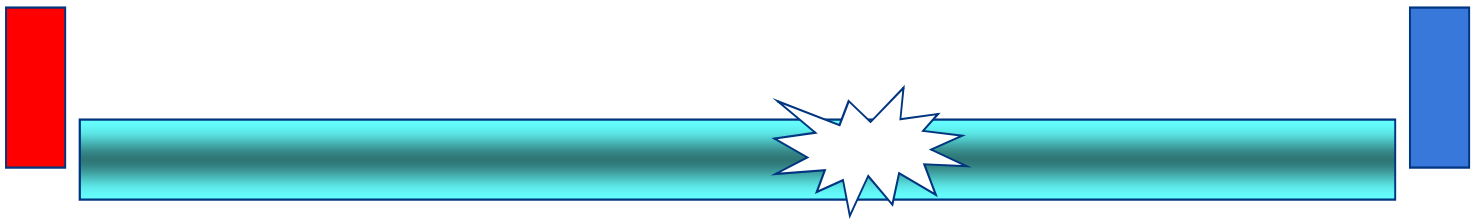
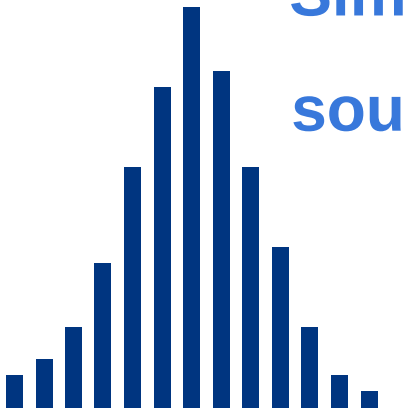
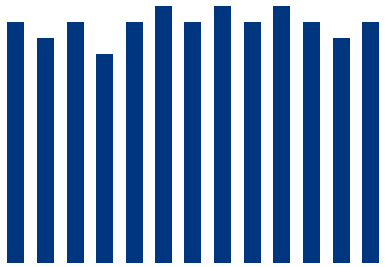
To obtain a good correlation display, noise MUST be heard at each sensor.



Similar sounds



Dissimilar sounds



Correlation

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We must give the correlator basic information for the correlator to give us a result :-

- **Distance**
- **Pipe Diameter**
- **Pipe Material**
- **Velocity (generally automatically calculated)**

Correlation Formula

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$$L = \frac{D - (V \times Td)}{2}$$

L = Leak position (m) (metres)

D = Length of pipe (m) (metres)

V = Velocity of sound along pipe (m/ms) (metres per millisecond)

Td = time delay (ms) (milliseconds)

Correlation Calculations

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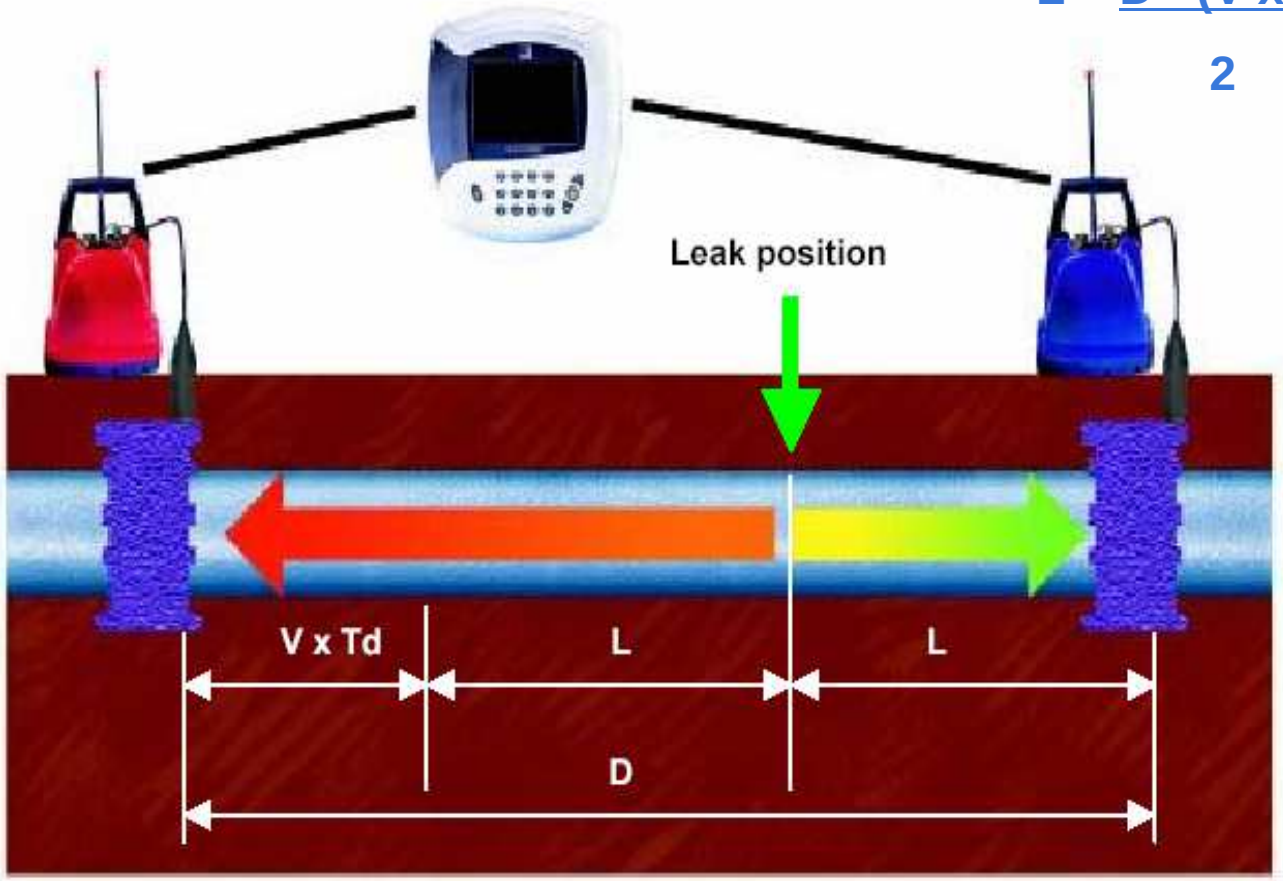
$$L = \frac{D - (V \times Td)}{2}$$



Time Delay

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If a leak was exactly midway between the two correlation points, the noise pattern would be identical.

If a leak correlated is closer to one sensor then there is a "Time Delay"(of only a fraction of a second) for noise to reach the furthest sensor.

The smaller the "Time Delay" the more accurate the result

Factors Affecting Velocity

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Velocity is the speed at which sound travels through a pipe

- **Material - Metallic faster, Plastics slower**
- **Size - The larger the pipe the slower the velocity**
- **Age (Internal Condition)**
- **Repairs (Mixed Materials)**

Correlation Formula

D = 100m, v = 1m/ms, Td = 80ms towards blue

Substitute in correlation formula

$$L = \frac{100 - (1 \times 80)}{2}$$

$$= \frac{100 - 80}{2}$$

$$= \frac{20}{2}$$

= 10m (Blue)

Order of calculation

1. ***Multiply***
2. ***Subtract***
3. ***Divide***

Calculating With Wrong Distance

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IF Velocity = 1.28, Time Delay = 28.2 & Distances change from 150, 145, 120m

$$L=\frac{150 - (1.28 \times 28.2)}{2} \qquad L=\frac{150 - 36.09}{2} \qquad L=\frac{113.91}{2}$$ **Length= 56.95m**

$$L=\frac{145 - (1.28 \times 28.2)}{2} \qquad L=\frac{145 - 36.09}{2} \qquad L=\frac{108.91}{2}$$ **Length= 54.45m**

$$L=\frac{120 - (1.28 \times 28.2)}{2} \qquad L=\frac{120 - 36.09}{2} \qquad L=\frac{83.91}{2}$$ **Length= 41.95m**

Calculating With Wrong Velocity

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IF Time Delay = 28.2, Distances 150m & Velocity change from 1.28, 1, 0.4

$$L=\frac{150 - (1.28 \times 28.2)}{2} \qquad L=\frac{150 - 36.09}{2} \qquad L=\frac{113.91}{2}$$ **Length= 56.95 m**

$$L=\frac{150 - (1 \times 28.2)}{2} \qquad L=\frac{150 - 28.2}{2} \qquad L=\frac{121.8}{2}$$ **Length= 60.90 m**

$$L=\frac{150 - (0.4 \times 28.2)}{2} \qquad L=\frac{150 - 11.28}{2} \qquad L=\frac{138.72}{2}$$ **Length= 69.36 m**

Calculating With Small Time Delays

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Advantages of having the leak in the central position between sensors when unsure of the velocity of the pipe.

IF Time Delay = 1.4, Distances 150m & Velocity change from 1.28, 1, 0.4

$L=\frac{150 - (1.28 \times 1.4)}{2}$	$L=\frac{150 - 1.792}{2}$	$L=\frac{148.21}{2}$	**Length= 74.10 m**
$L=\frac{150 - (1 \times 1.4)}{2}$	$L=\frac{150 - 1.4}{2}$	$L=\frac{148.60}{2}$	**Length= 74.30 m**
$L=\frac{150 - (0.4 \times 1.4)}{2}$	$L=\frac{150 - 0.56}{2}$	$L=\frac{149.44}{2}$	**Length= 74.72 m**

Calculating With Large Time Delays

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The leak position in these examples is closer to one sensor than the other, therefore a larger Td

IF Time Delay = 31.3, Distances 150m & Velocity change from 1.28, 1, 0.4

$$L=\frac{150 - (1.28 \times 31.3)}{2} \qquad L=\frac{150 - 40.06}{2} \qquad L=\frac{109.94}{2} \qquad \text{Length= 54.97 m}$$

$$L=\frac{150 - (1 \times 31.3)}{2} \qquad L=\frac{150 - 31.3}{2} \qquad L=\frac{118.70}{2} \qquad \text{Length= 59.35 m}$$

$$L=\frac{150 - (0.4 \times 31.3)}{2} \qquad L=\frac{150 - 12.52}{2} \qquad L=\frac{137.48}{2} \qquad \text{Length= 68.74 m}$$

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Rubbish In
=
Rubbish Out

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Basic on Site Setup

Sensor Positioning

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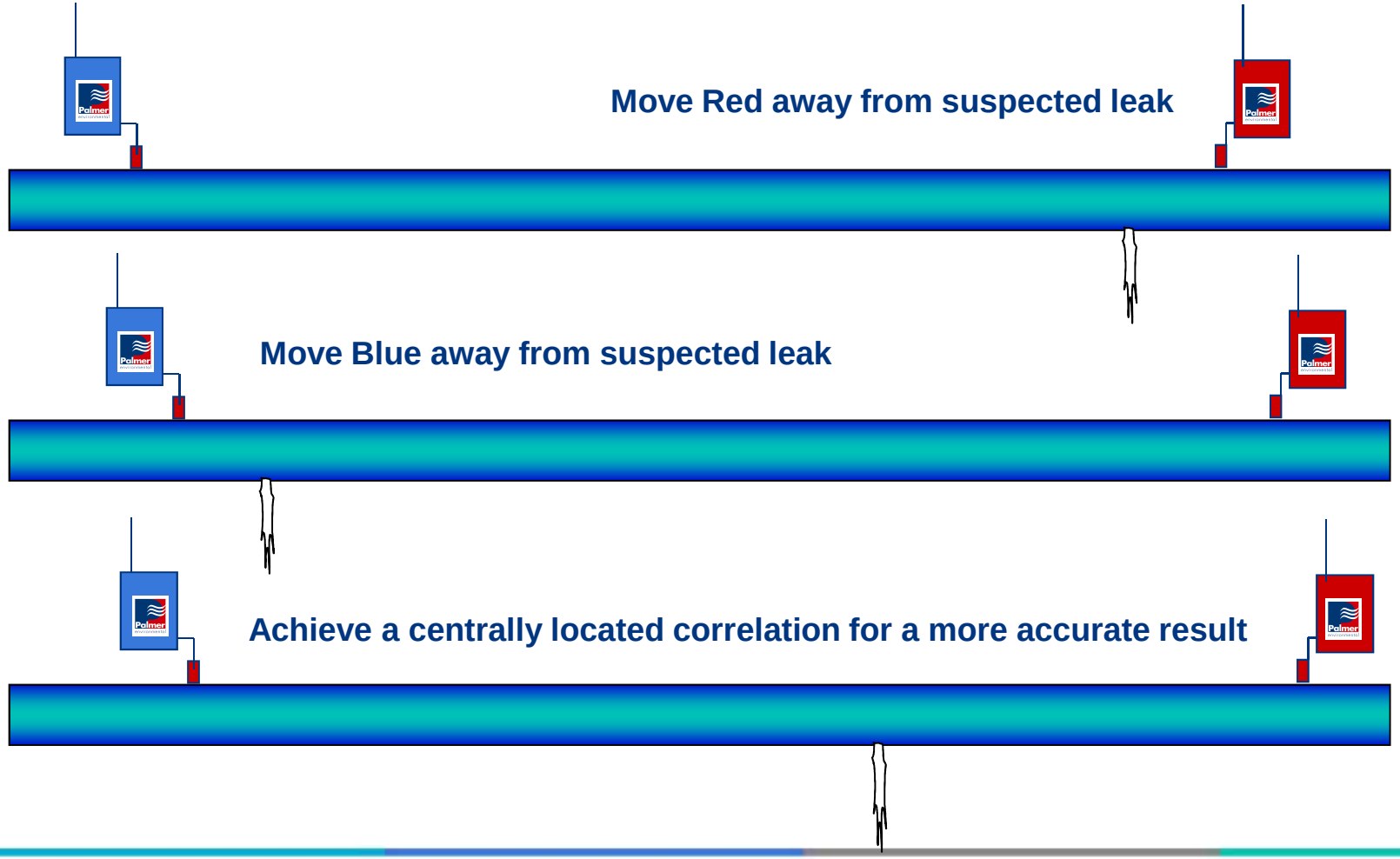

Sensor Positioning

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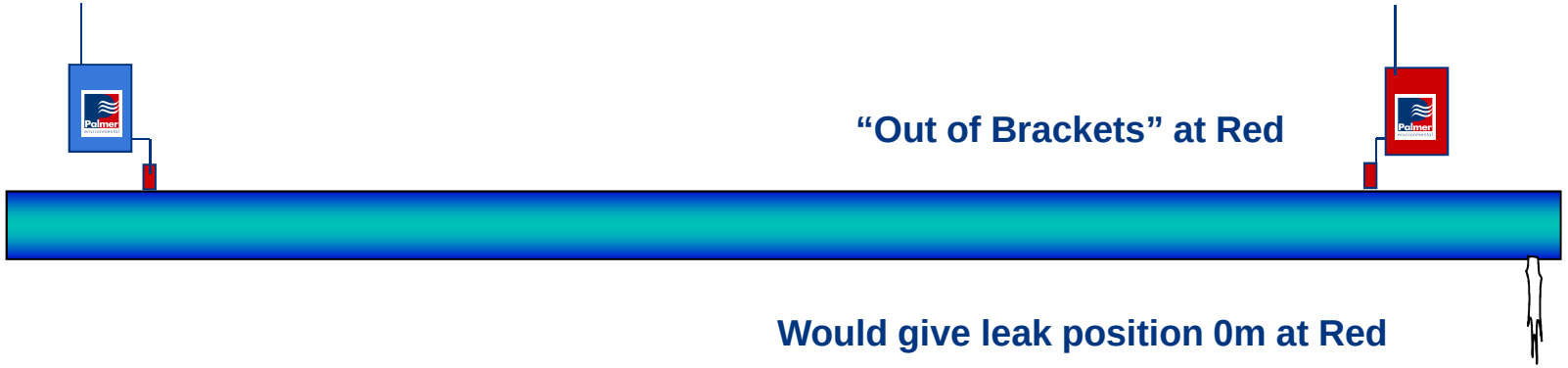

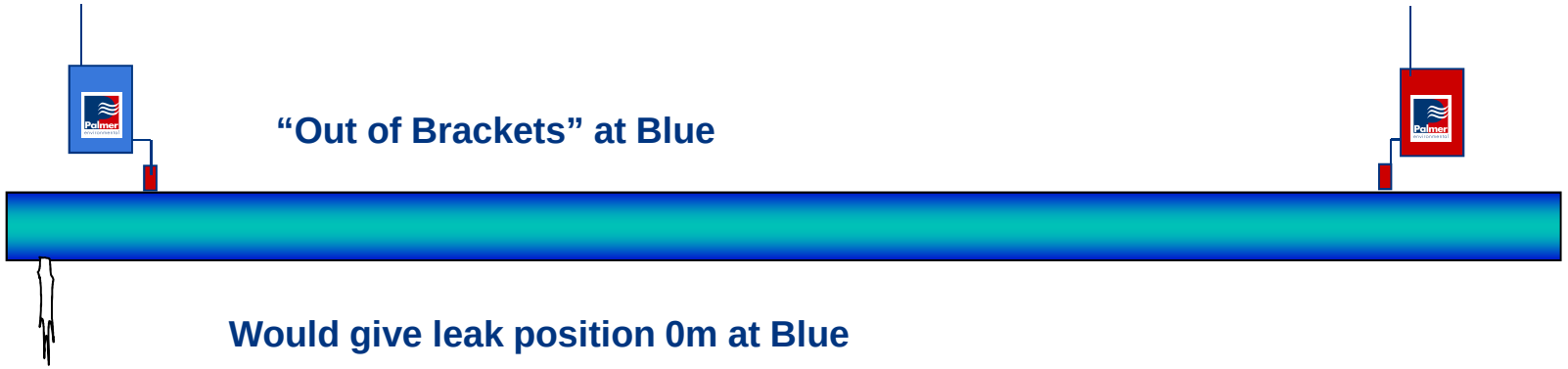

Sensor Positioning

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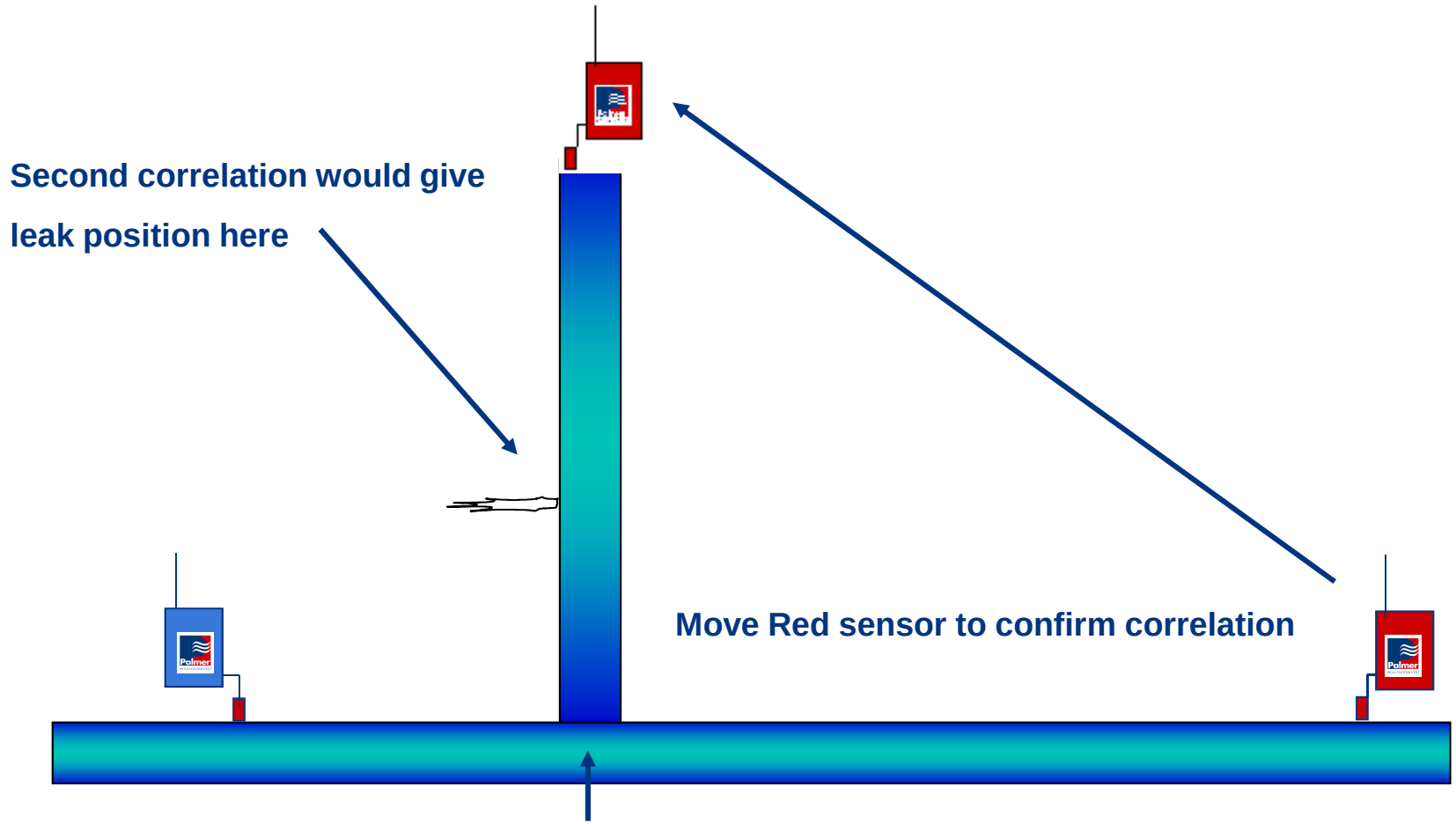

Distance Measuring

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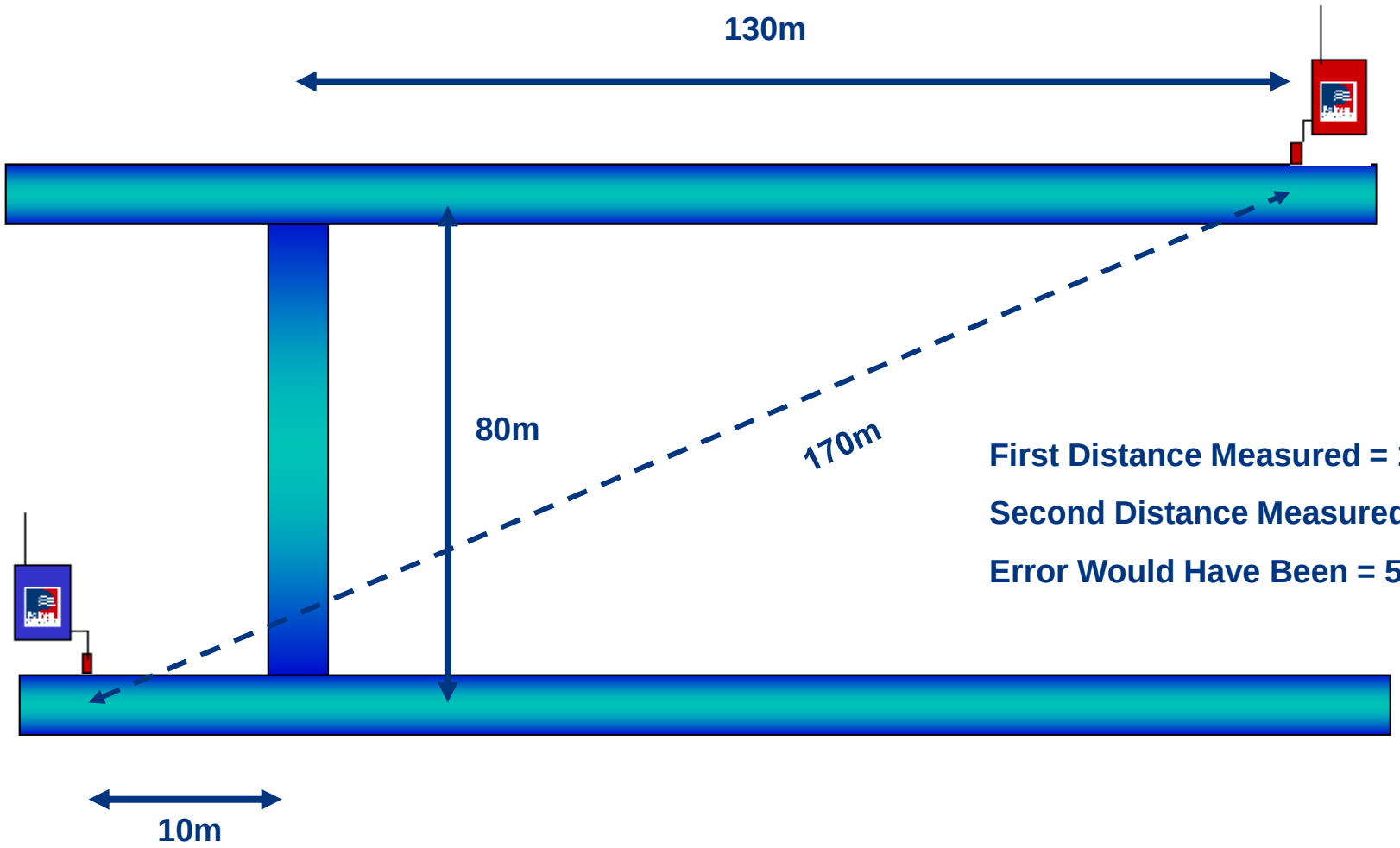
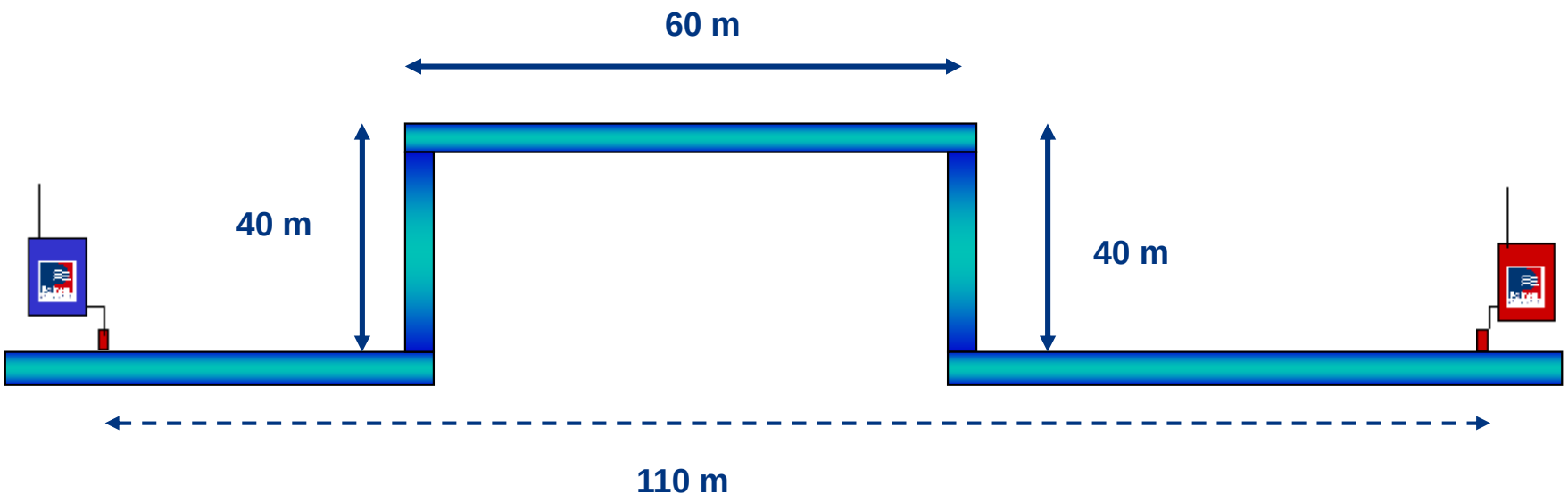


First Distance Measured = 170m

Second Distance Measured = 220m

Error Would Have Been = 50m

Distance Measuring



First Measurement = 110 m

Second Measurement = 190 m

Error Would Have Been = 80 m

Distance Measuring

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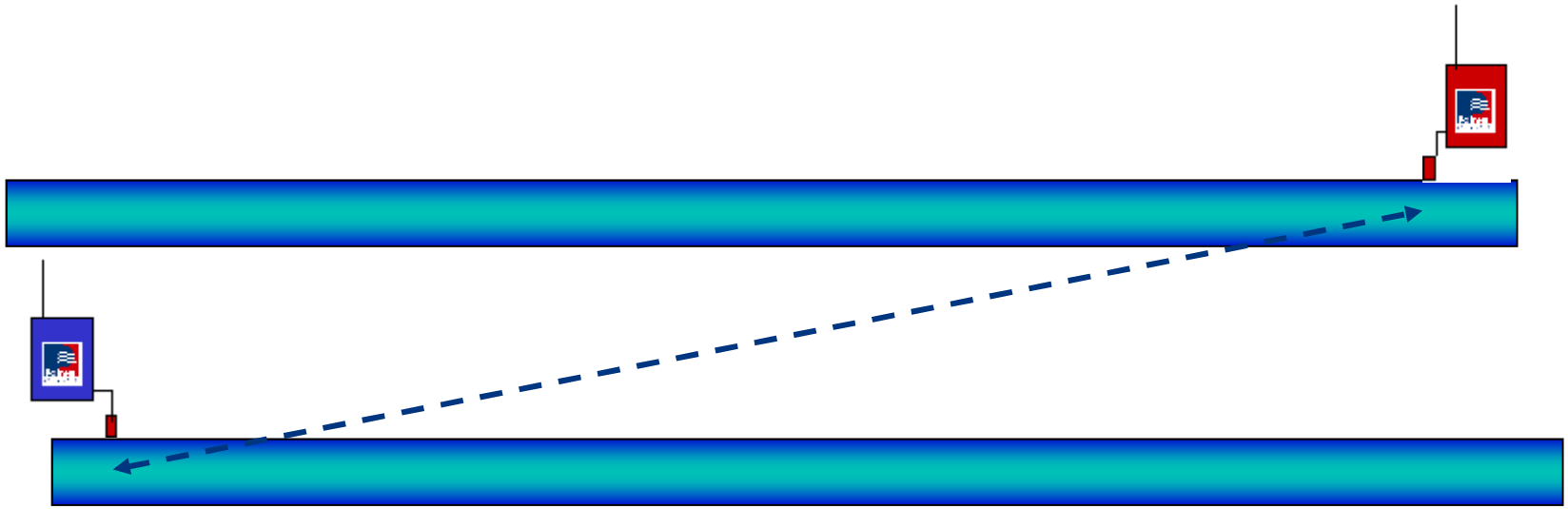

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Outstations

Outstations

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1 - On / Off

2 - Sensor

3 - Aerial

4 - Charge / Headphones

Outstations

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The outstations are turned on via the small button on the Front

Press once and the green LED button will flash

To turn outstation off, hold down button for two seconds, the green LED will stop flashing

Outstations

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You can listen direct at the outstations via the headphones. This can only be done when no correlation is taking place

To check the sensor is working ok perform a “tickle test”

Plug both sensor and and headphones into the outstation

Gently rub your finger over the sensors magnet, you should be able to here crisp, clean sound. If no sound is heard you may have a fault and will not correlate correctly

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Interface Unit

Interface Unit

1 - Headphones & charging

2 - Sensor

3 - Aerial

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Charging

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The interface unit is charged from flat in 6 hours

The outstations are charged from flat in 5 hours

The batteries can’t be overcharged

Charging

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After connecting charger cables ……

The interface unit will turn ON automatically. The interfaces large green LED will light constantly while charging, then flash rapidly when almost fully charged.

The outstations will turn ON automatically. The outstations green LED will light constantly while charging, then flash rapidly when almost fully charged.

All units automatically turn off when unplugged

Setting Up

Setting Up

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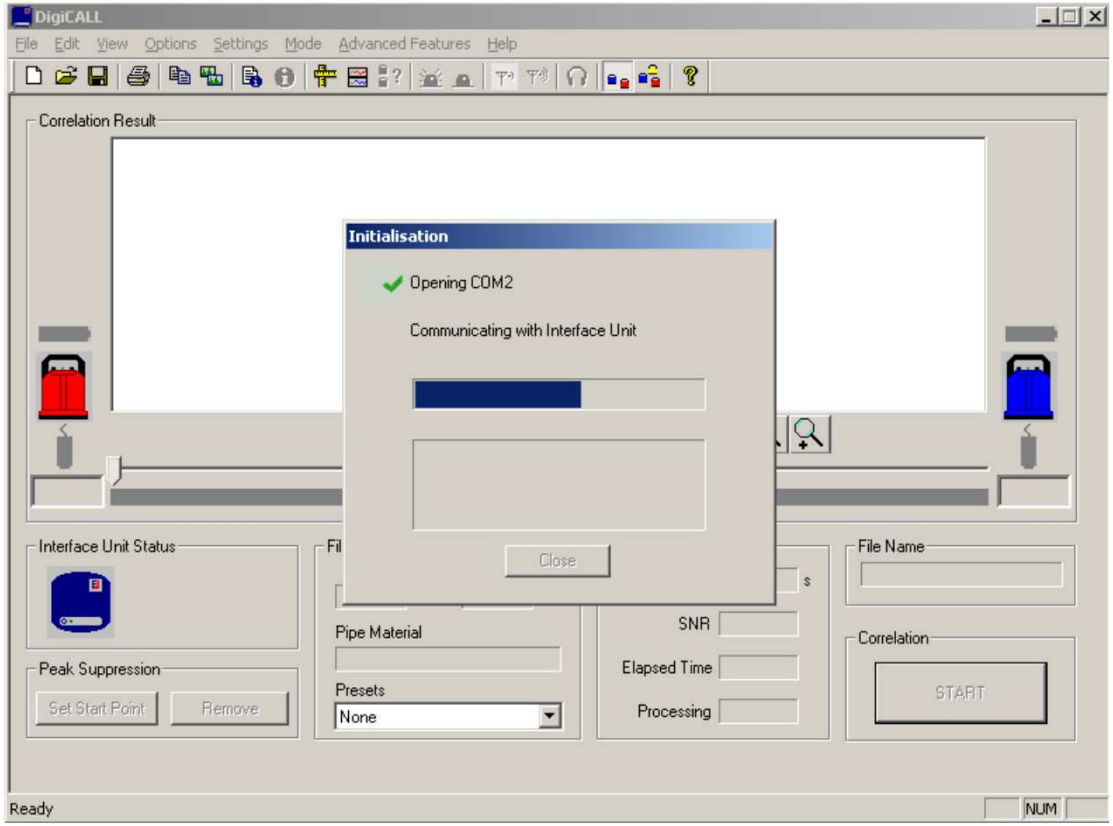
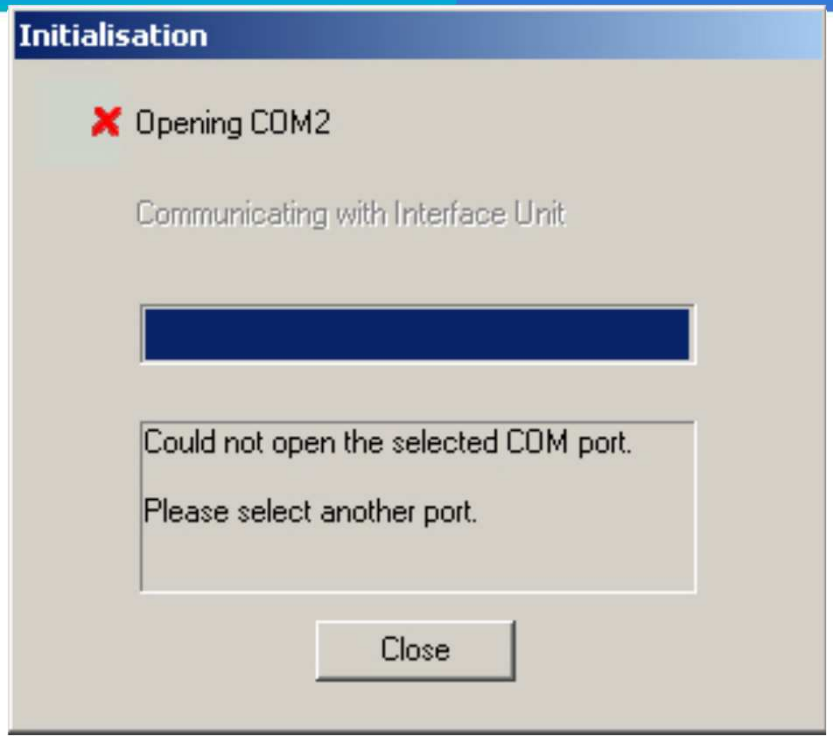


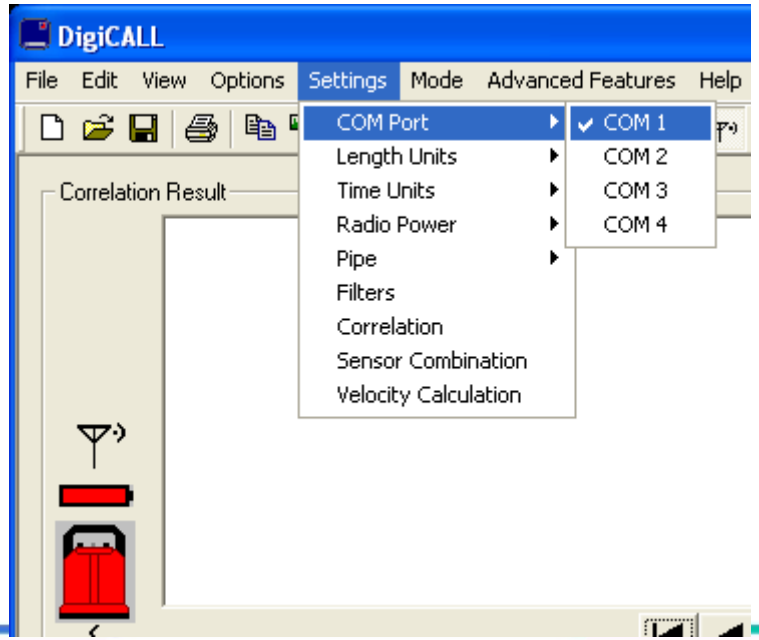
Start the DigiCall software on PC

Setting Up

Halma Water Management



Depending on PC you may have to change com port



Main Screen

Main Screen

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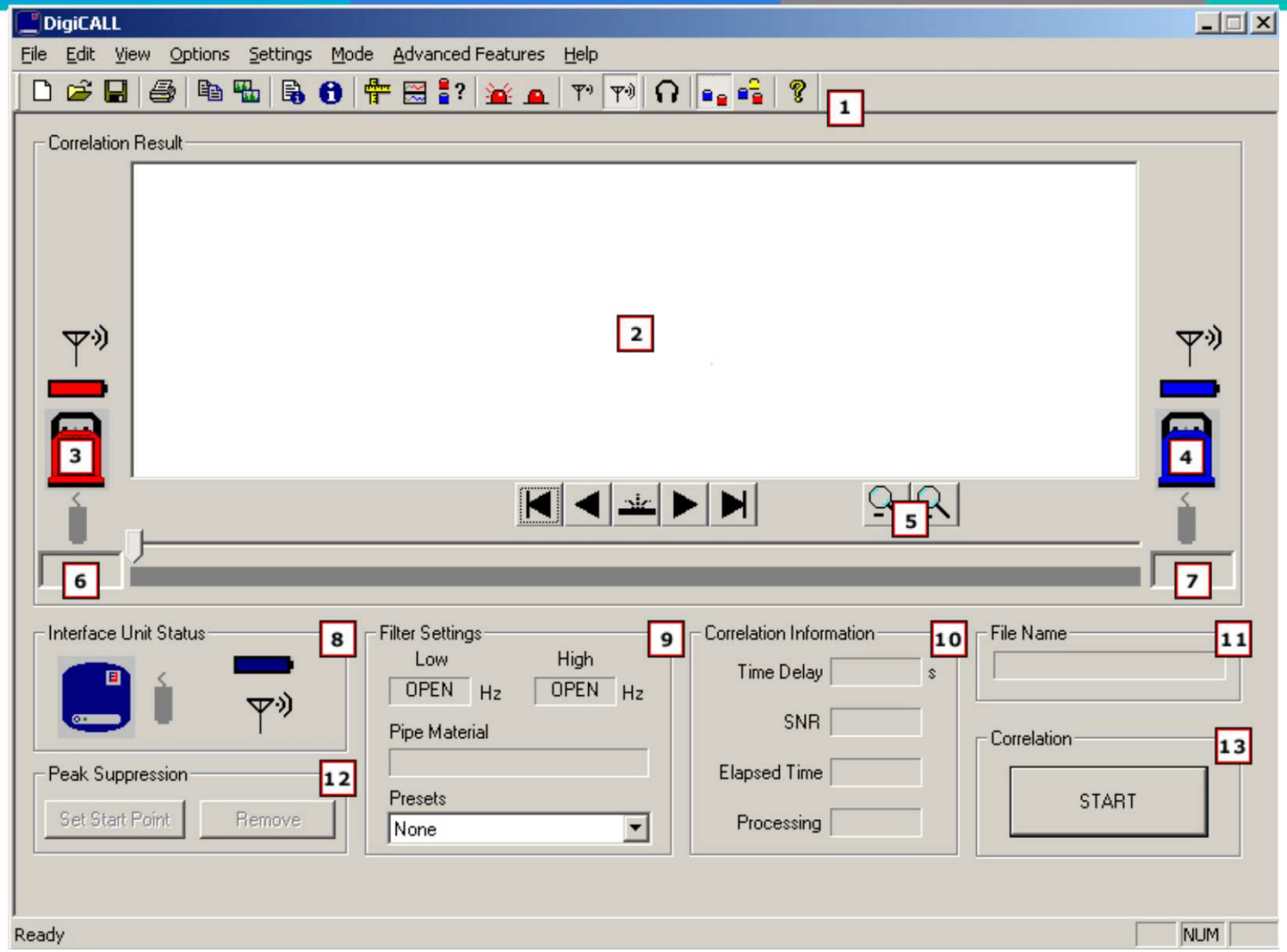

Main Screen

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1 - Tool bar

2 - Correlation display

3 - Red outstation status

4 - Blue outstation status

5 - Zoom in / out

6 - Leak distance from red sensor

7 - Leak distance from blue sensor

8 - Interface unit status

9 - Filter settings

10 - Correlation information

11 - Correlation file name

12 - Peak suppression option

13 - Start / stop correlation

Main Screen

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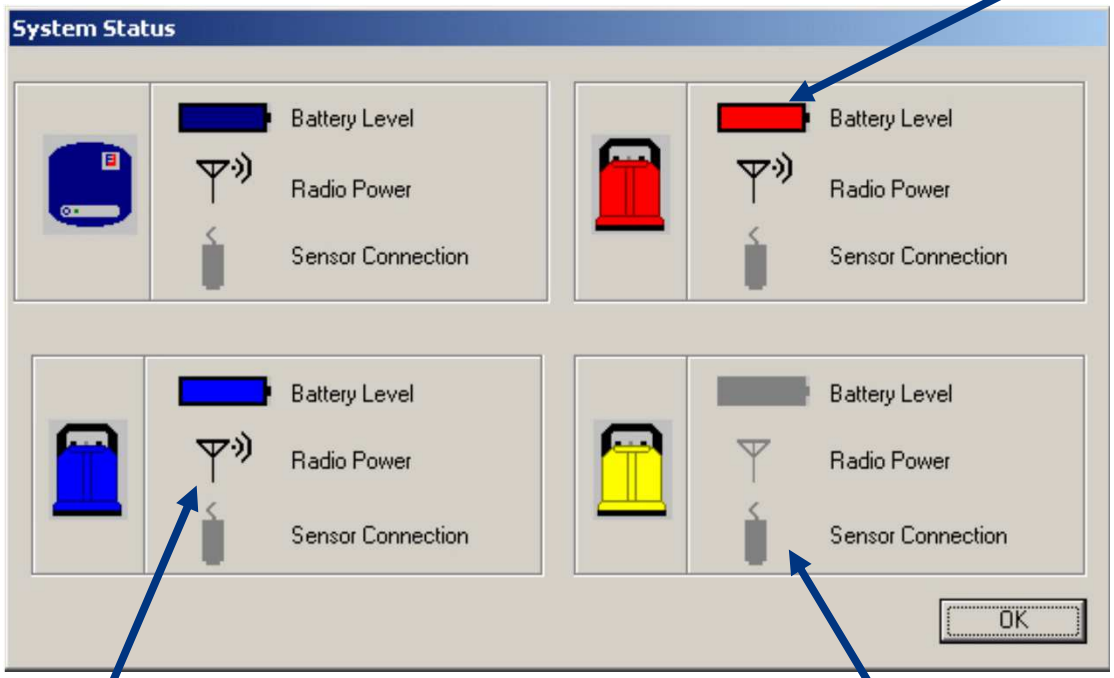
Indicates full battery



Indicates high radio power

.) is low .)) is high

Indicates nothing working

or not communicating

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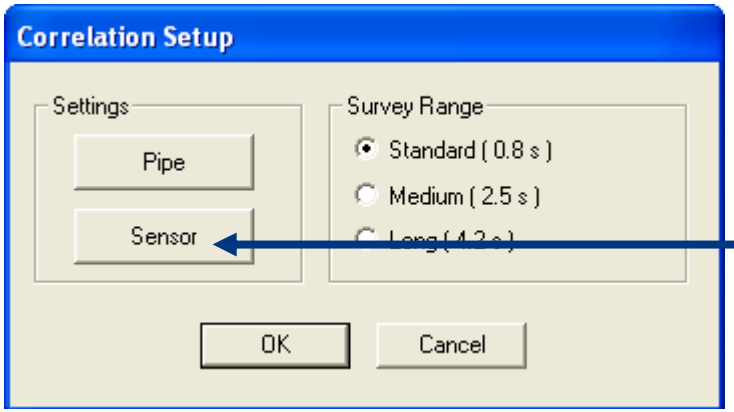
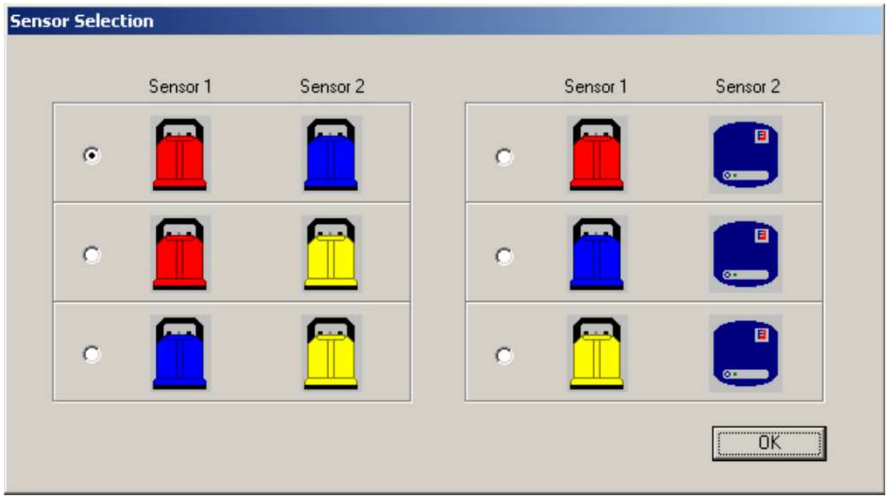
Performing a Correlation

Performing a Correlation



Click on “Start” from main screen, then click “Sensor”



Select sensor combination, then click “Ok”, then click “Ok” again from the screen above

Performing a Correlation

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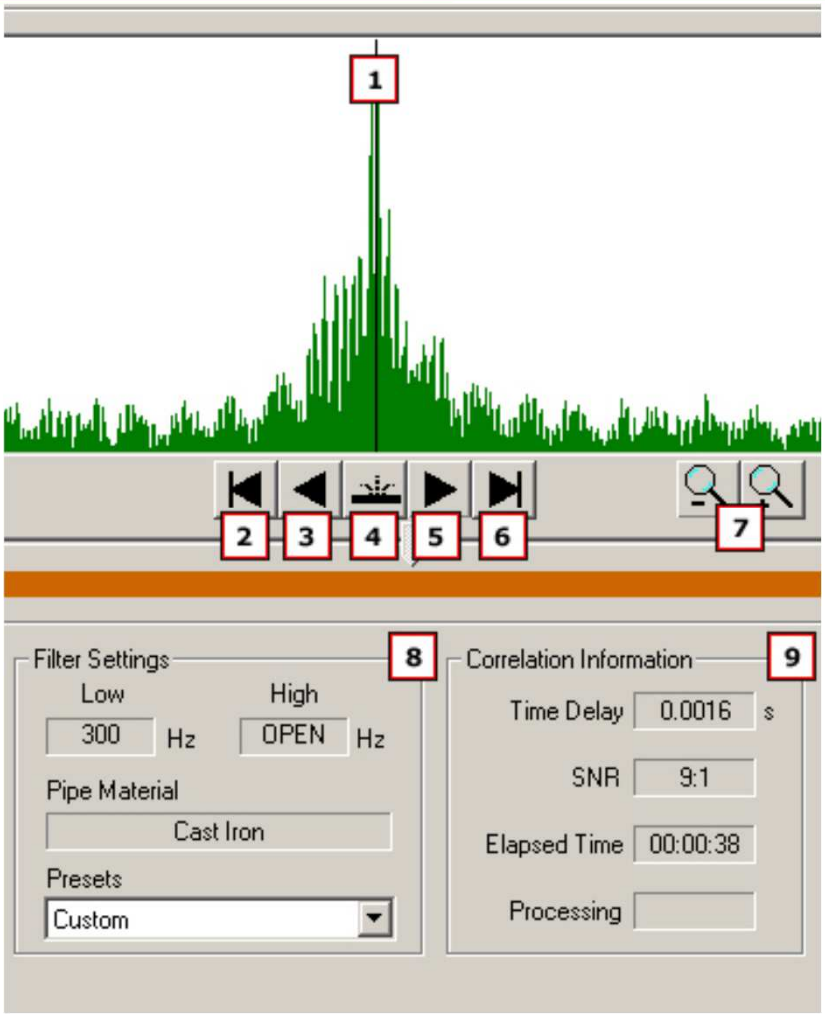

1 - Cursor (highest peak)

2 - Moves cursor to far left

3 - Moves cursor left

4 - Centres cursor on leak position

5 - Moves cursor right

6 - Moves cursor to far right

7 - Zoom in / out

8 - Filter settings

9 - Correlation information

- SNR (Signal Noise Ratio)

Pipe Data

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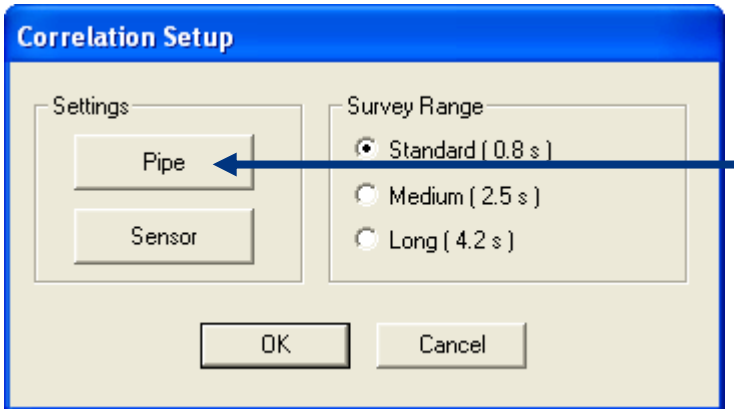
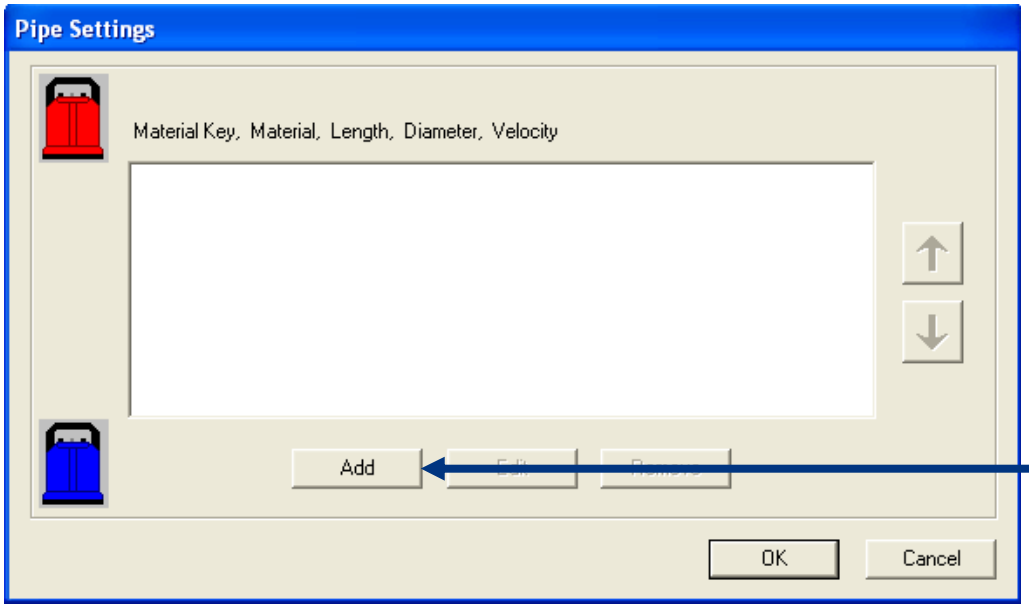
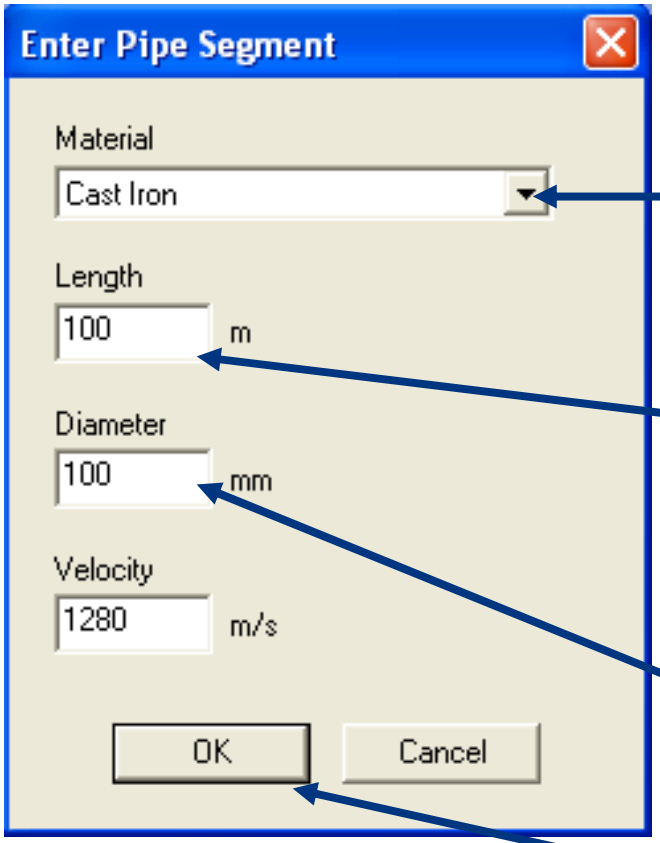


Click on “Start” from main screen, then click “Pipe”



Click on “Add”

Pipe Data



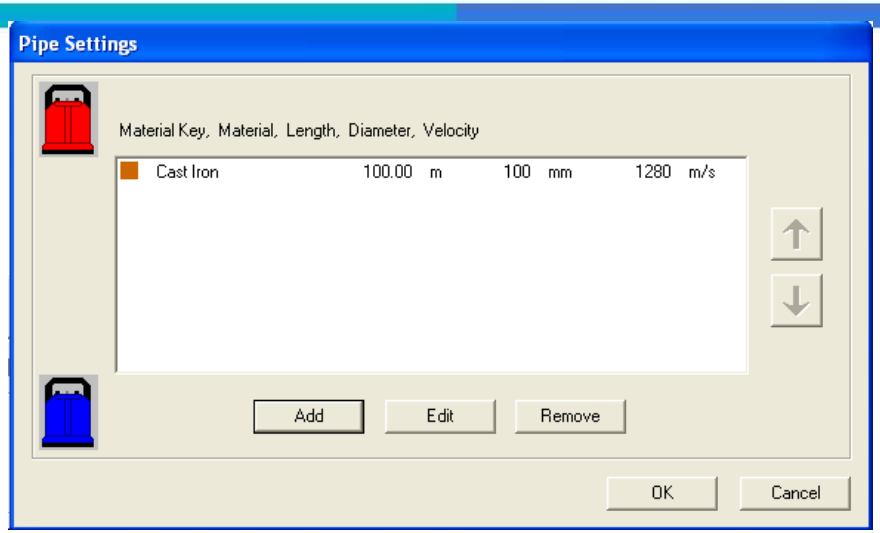
Click on “Material” and highlight correct material

Click in “Length” and enter correct length

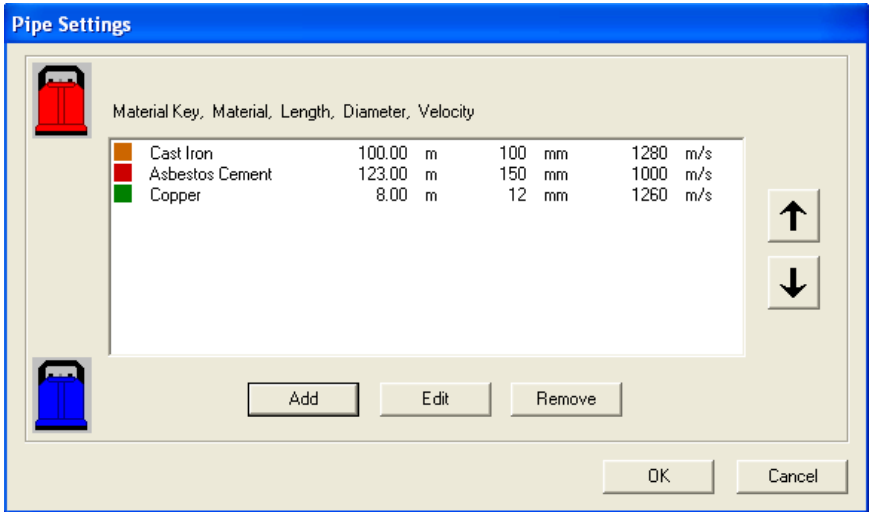
Click in “Diameter” and enter correct diameter

Then click “Ok”

Pipe Data



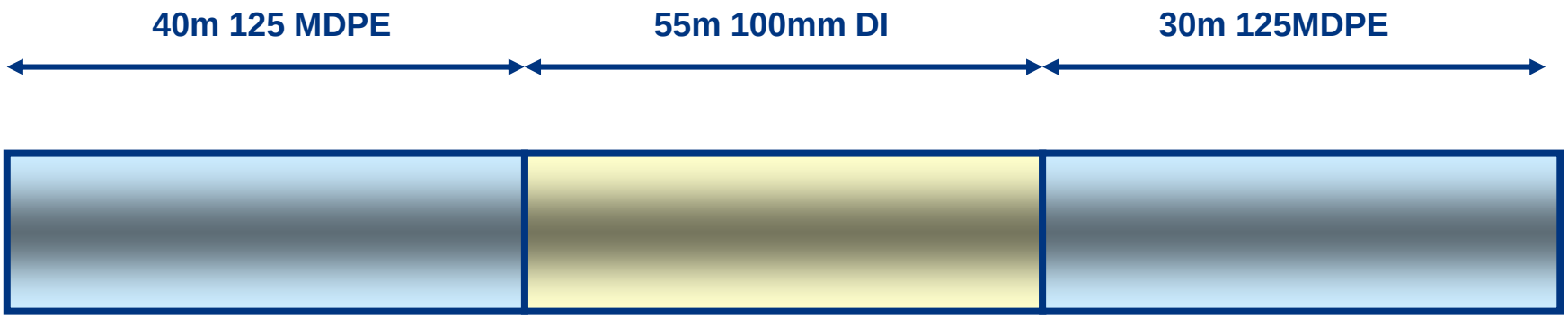
The selected data is displayed, to correlate click “Ok”, then click “Ok” again



To add more pipe data, click “Add” and enter the next material. Click “Ok” when finished to correlate, then click “Ok” again.

Up to 10 Multiple pipe entries

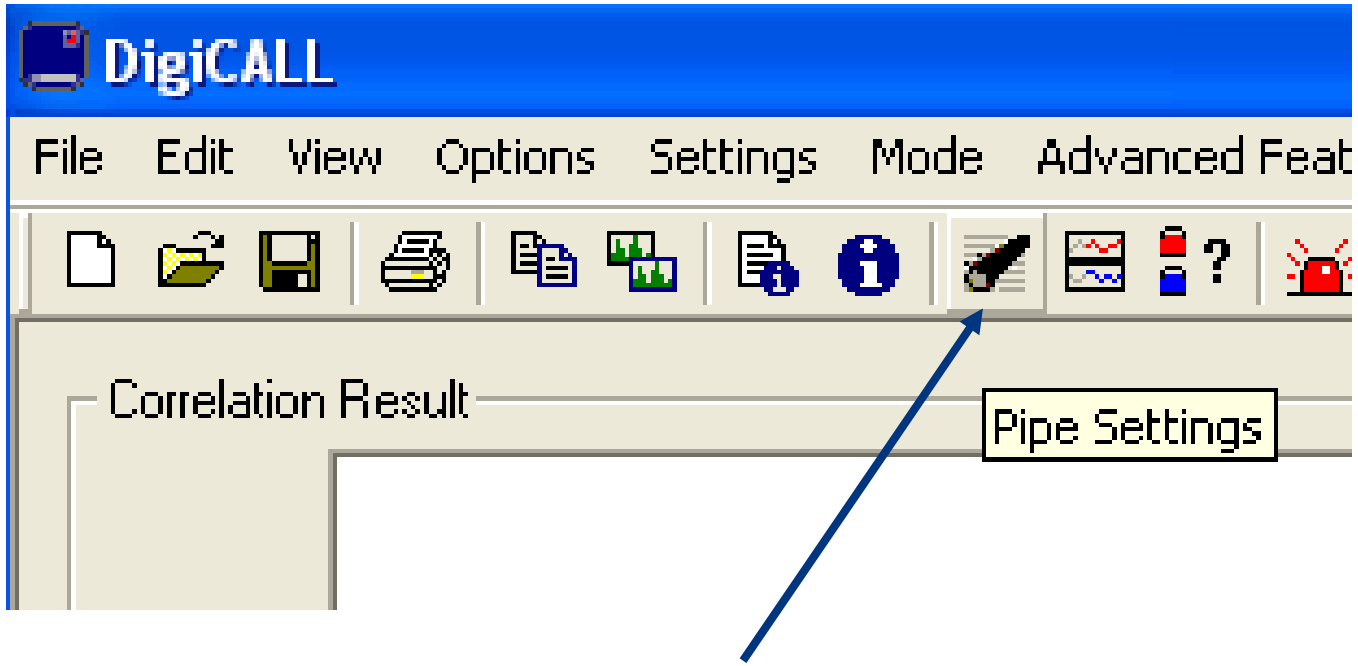
Mixed Material Function



This function is used where a stretch of main to be correlated contains 2 or more different materials or pipe diameters, thus changing the velocity of the pipe to be correlated.

Up to 10 different materials / sizes can be entered in a single correlation.

Pipe Data



To change pipe details after the first correlation, click on the "Pipe Settings" icon and change as previously shown, before re-correlating

Correlation Result

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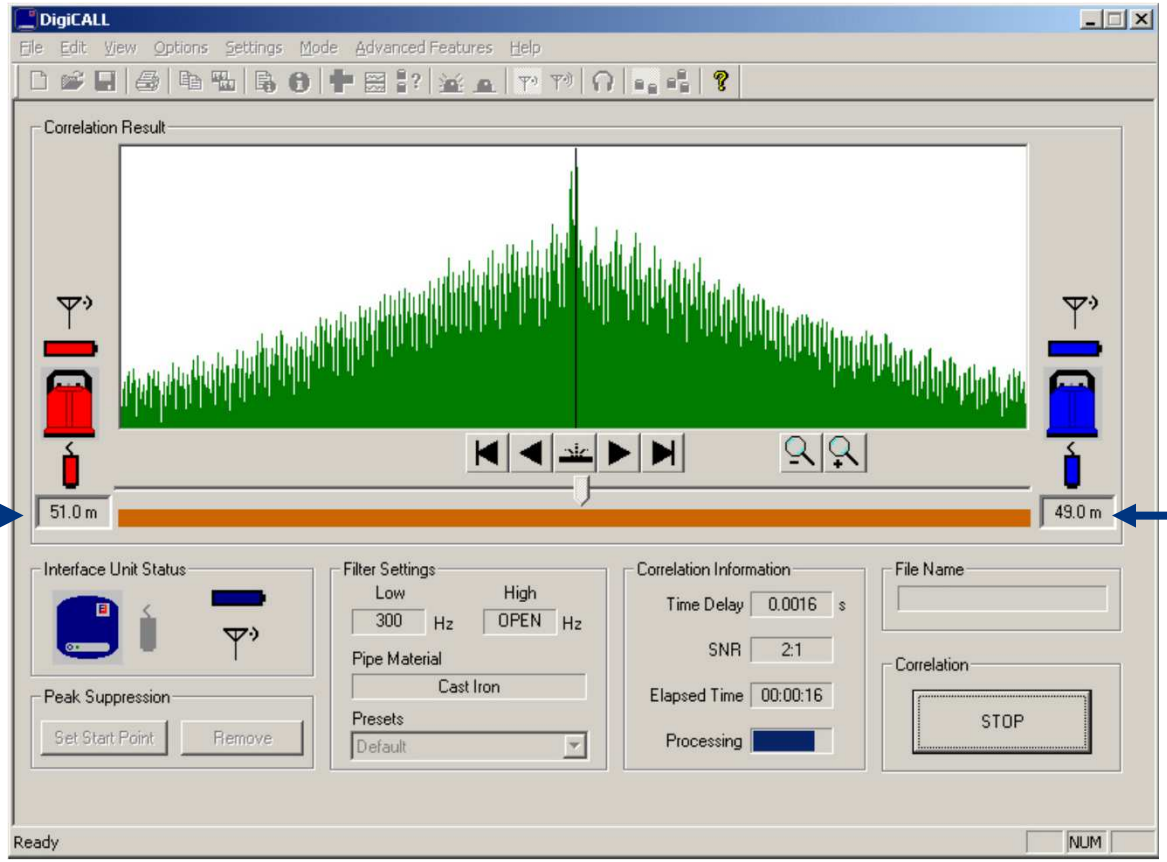
Leak position from RED



Leak position from BLUE

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Interpreting Results

Interpreting Results

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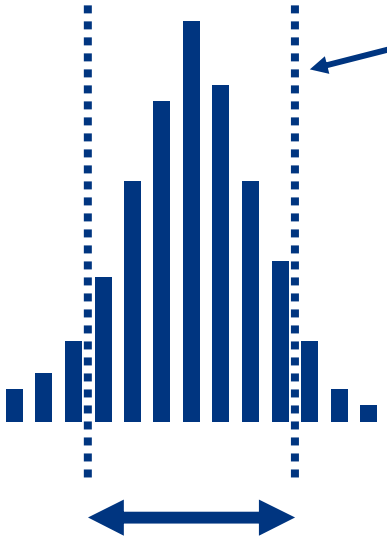
Shape of peak



Cursor

manually adjusted

This represents the area in the ground to investigate further

Generally:- Broad peaks = poor accuracy

Sharp peaks = greater accuracy

Interpreting Results

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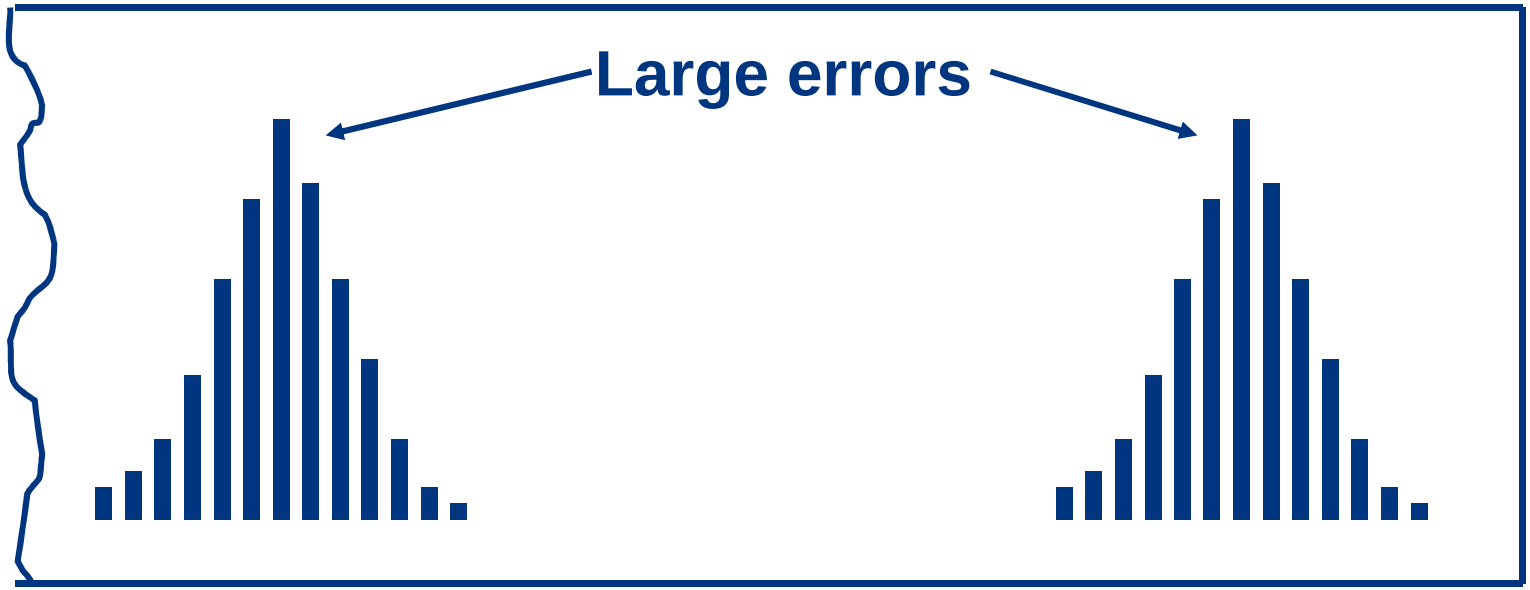
Position of peak



Velocity is very important!

Small velocity errors will lead to large leak position errors.

Never dig a hole based on a leak location close to a sensor, unless you have a very accurate measurement of velocity or other evidence indicates a leak at that point.

Interpreting Results

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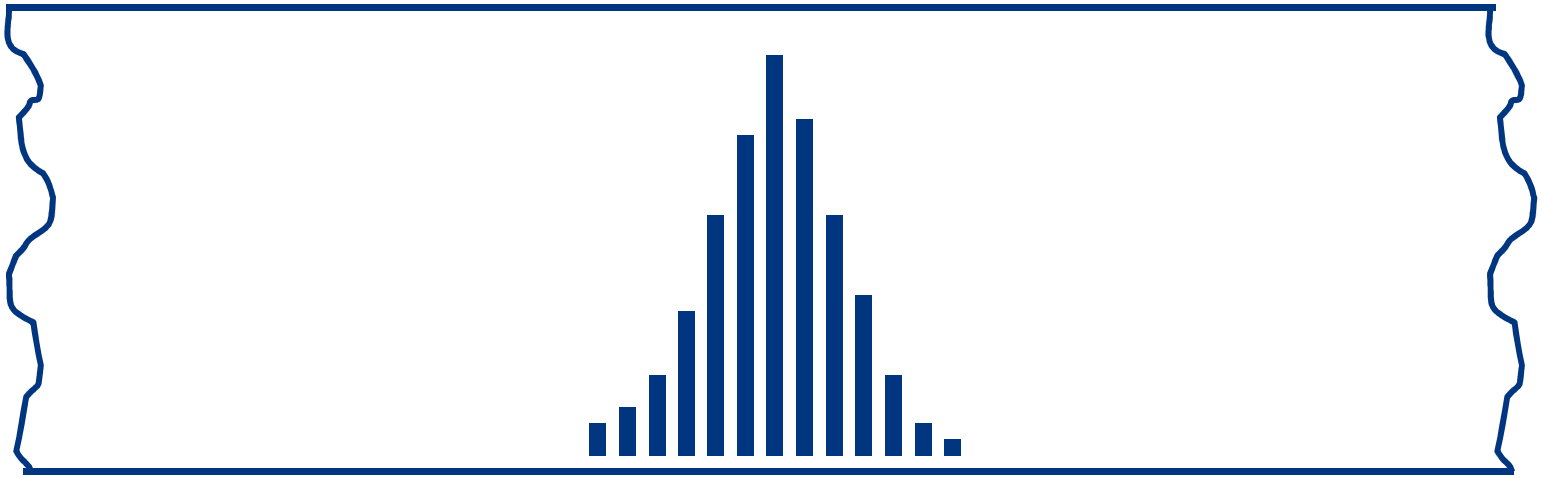
Position of peak



Ideal leak position is in the central area between the sensors but beware of centre correlation.

Velocity has little effect when a near central correlation.

Note:- Not Applicable on mixed materials.

In practice about +/- 20% from the centre.

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Extra Screen Information

Main Screen

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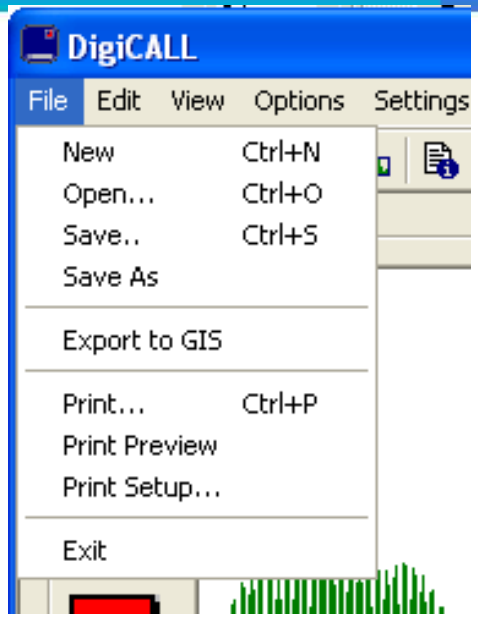
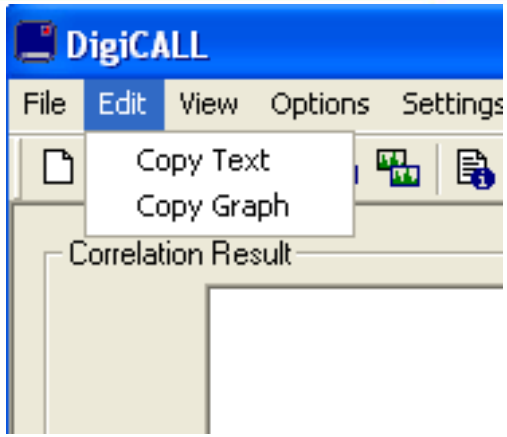
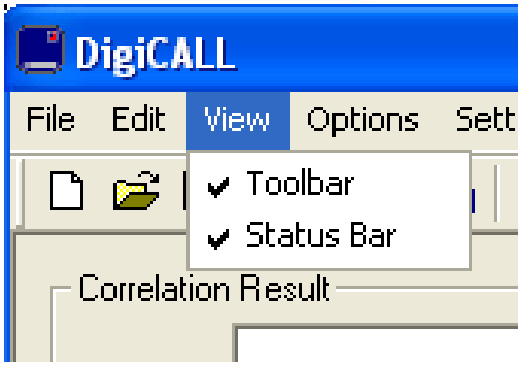
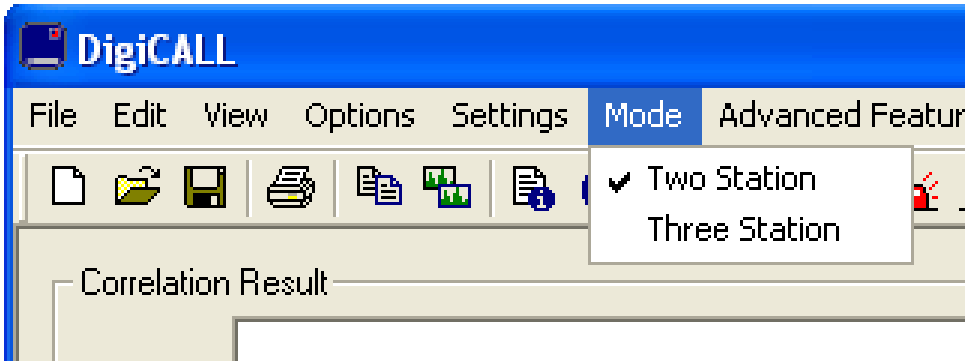


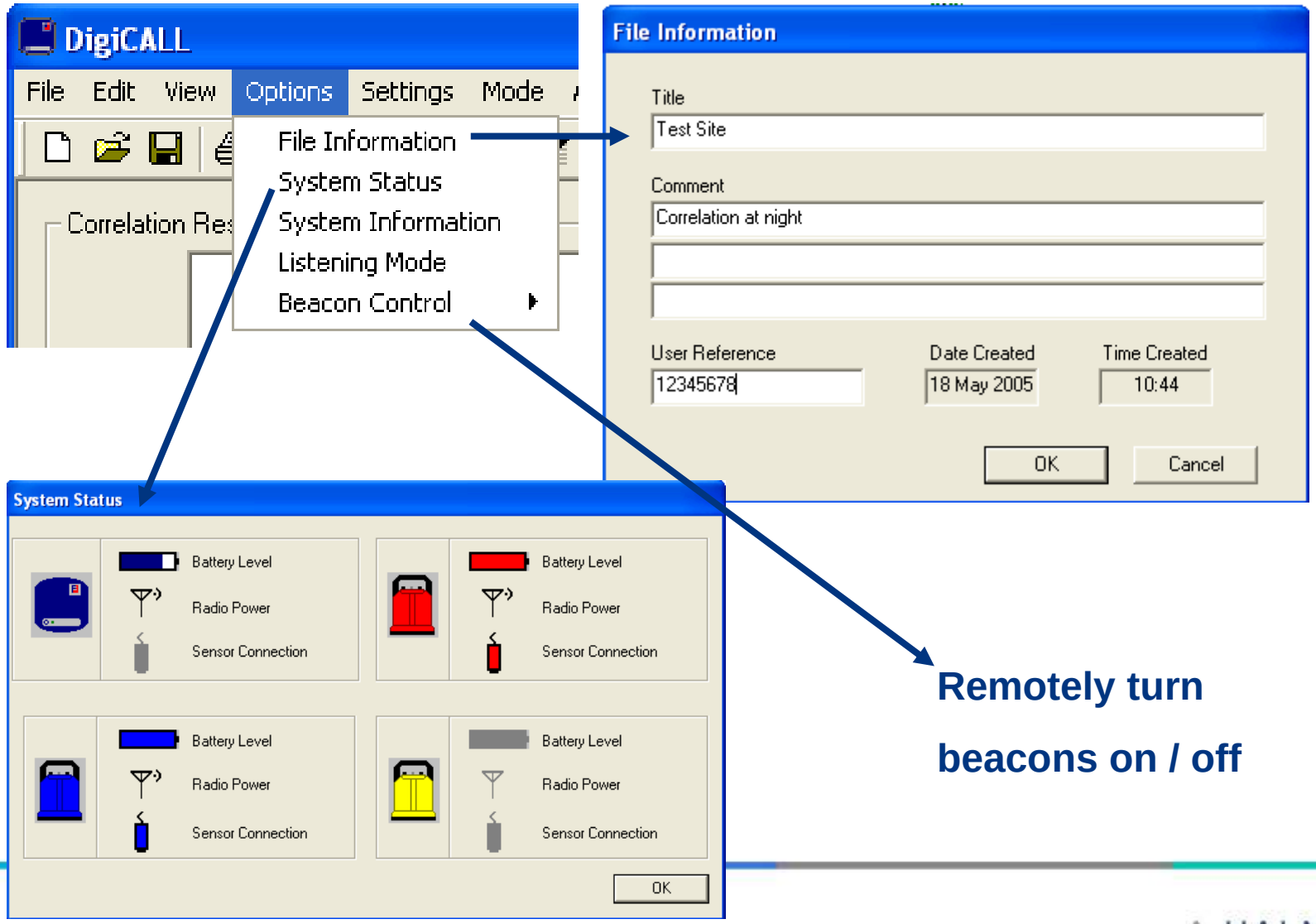






Main Screen

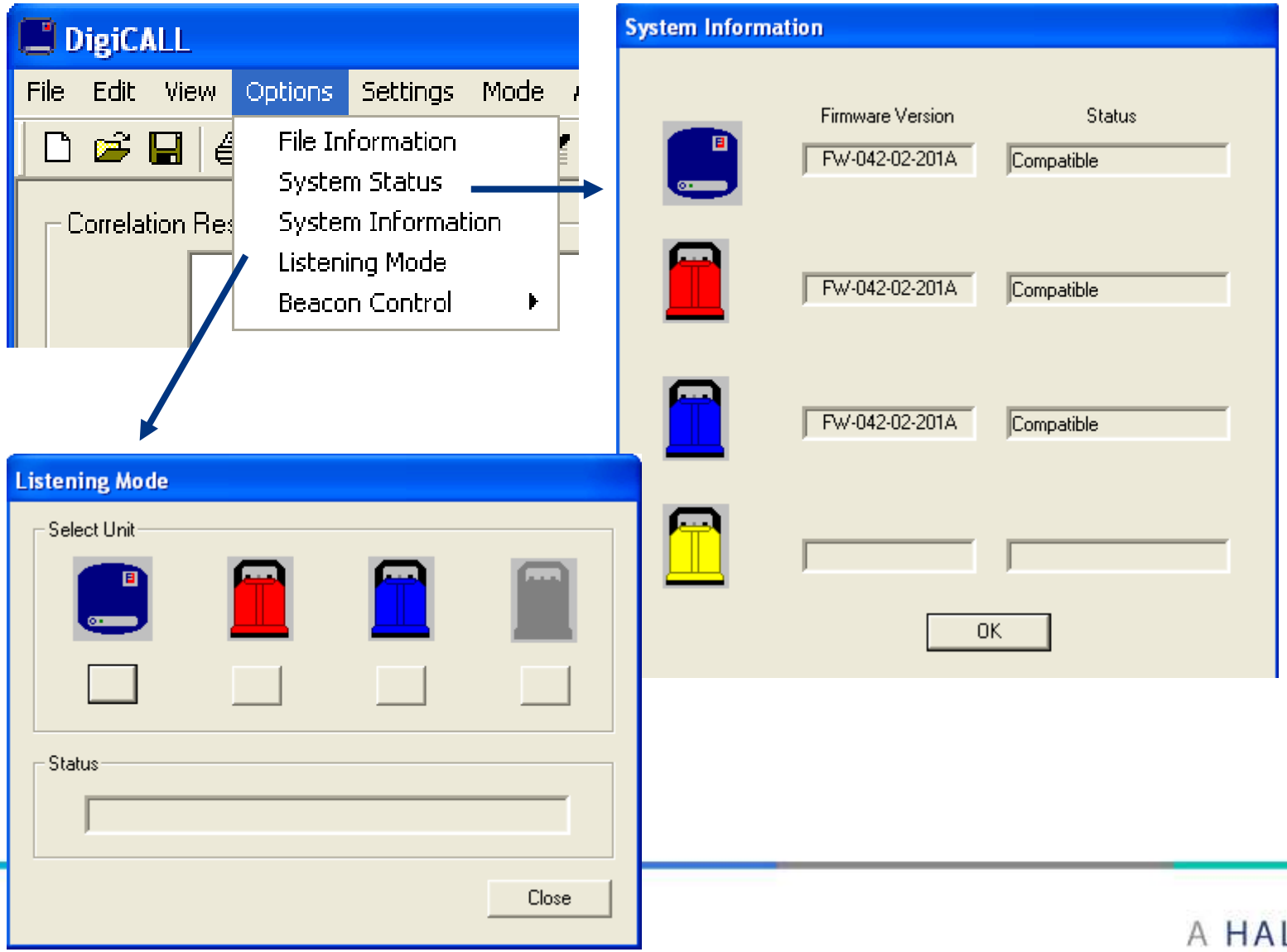
Halma Water Management



Remotely turn beacons on / off

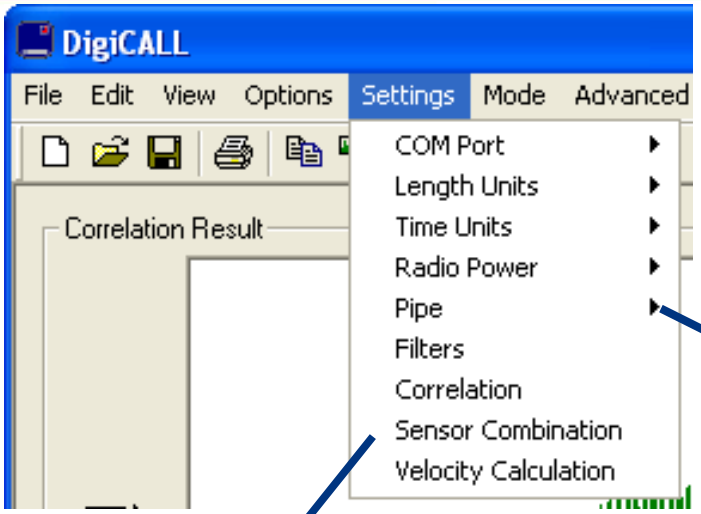
Main Screen

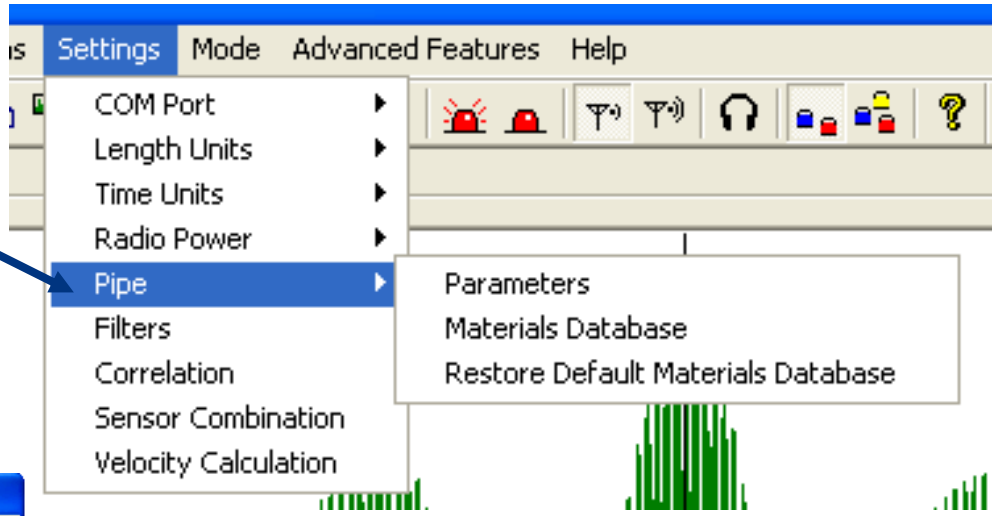
Halma Water Management

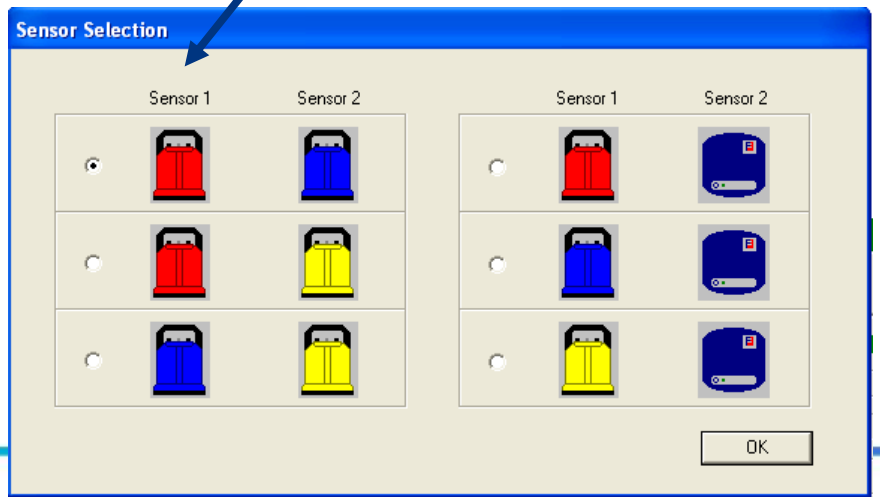


Main Screen

Halma Water Management

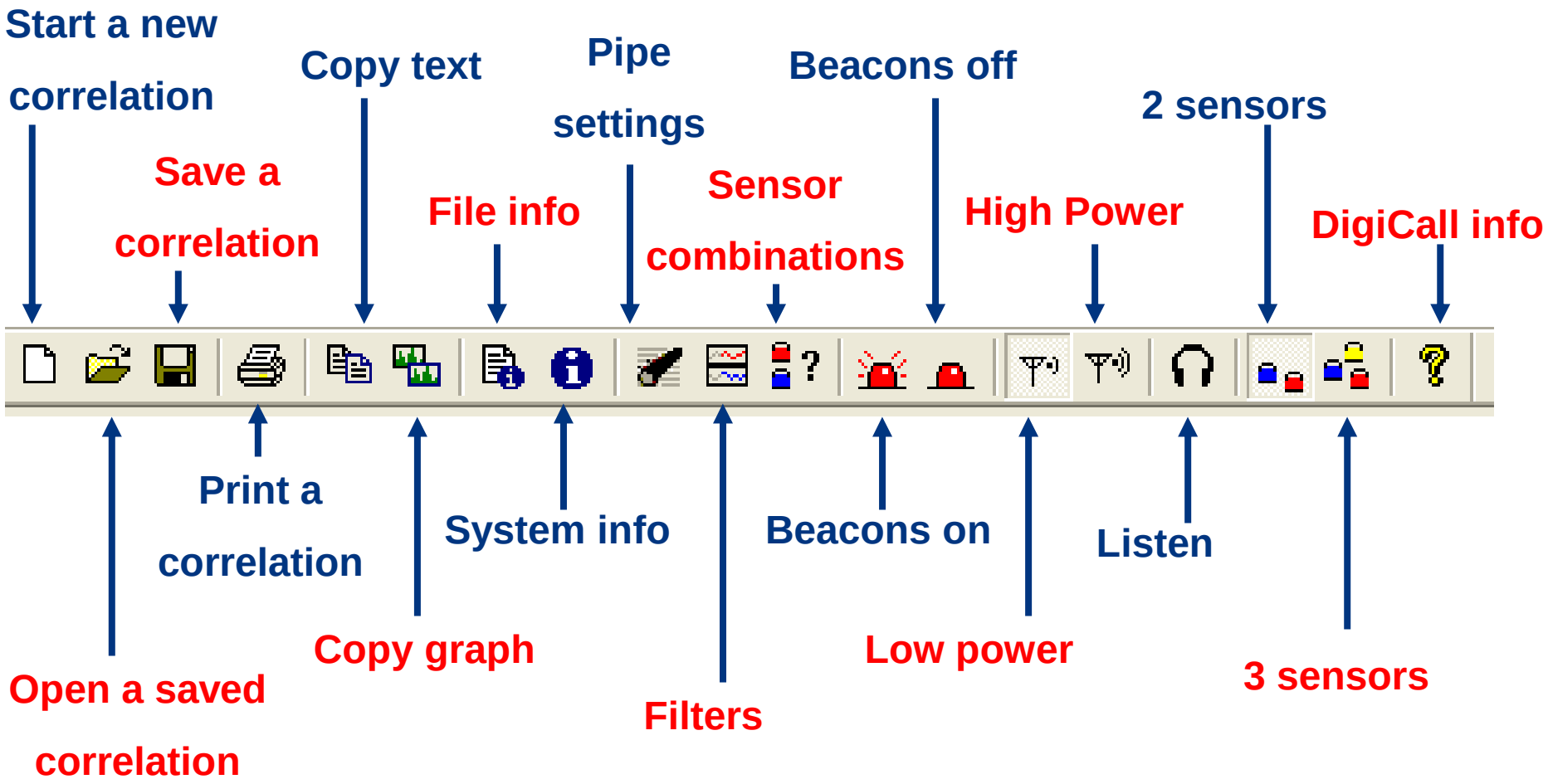






Main Screen

Halma Water Management



Halma Water Management

Filters

Why Alter Filters ?

Halma Water Management

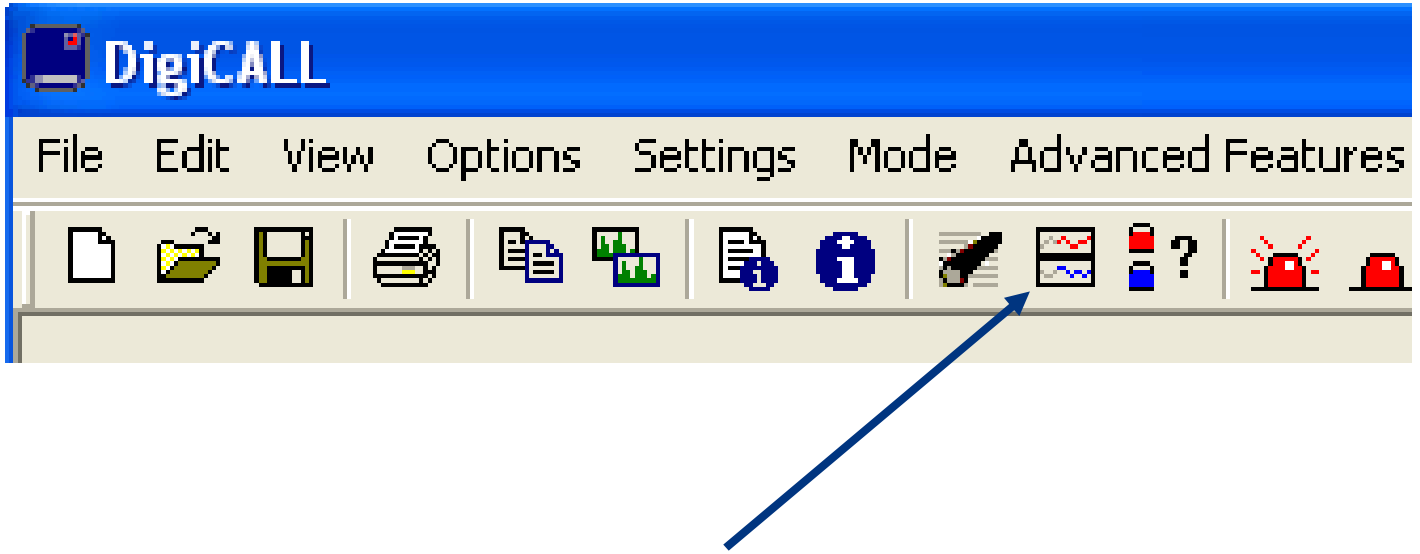
1. **To improve shape of peak.**

2. **To “unmask” hidden sources of noise.**

Lower frequencies occur on PLASTIC pipes

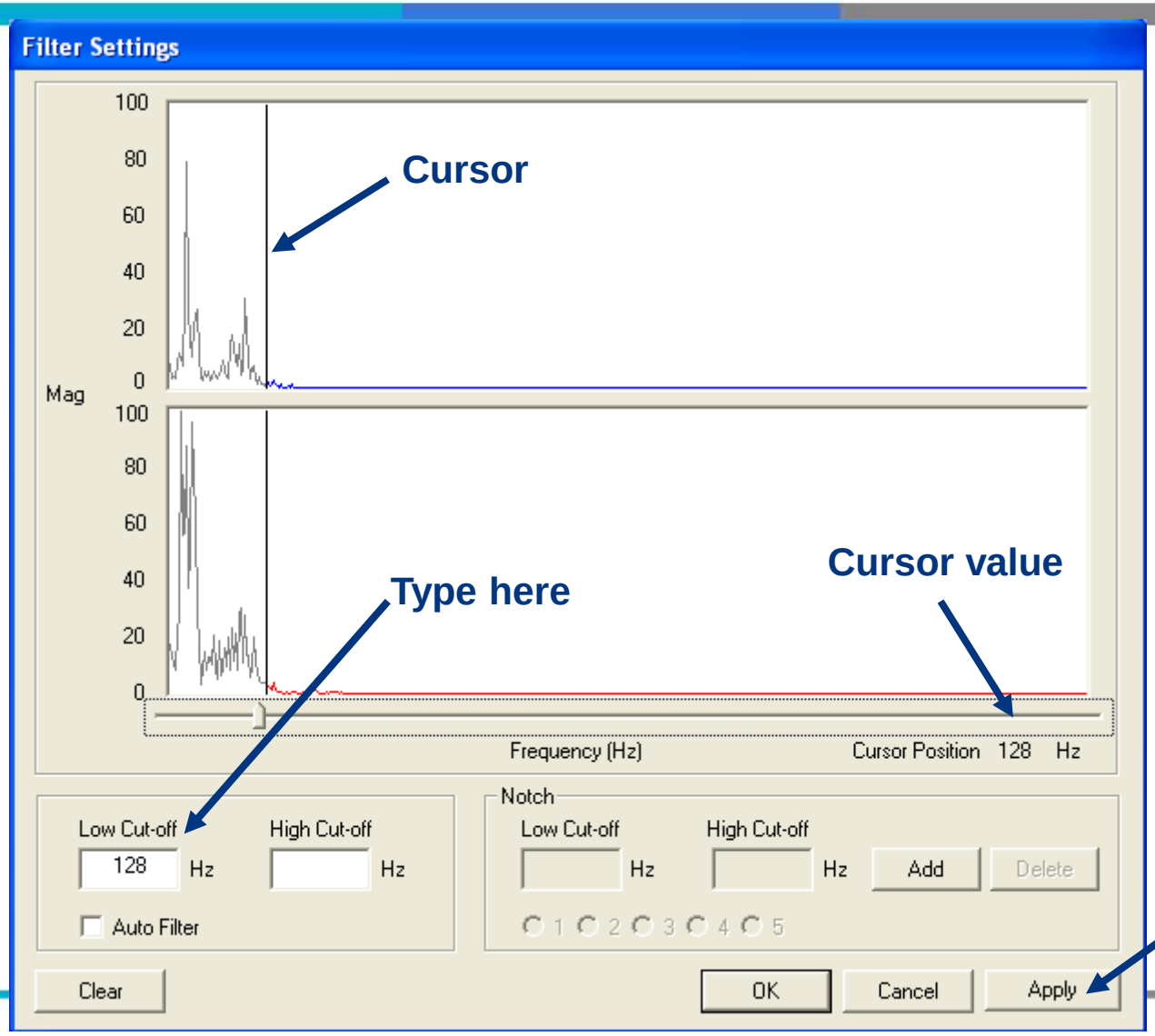
Higher frequencies occur on METALLIC pipes

To Change Filters



To change from default filter settings, click here from main tool bar

Low Cut Off



A low cut off is shown set at 128Hz

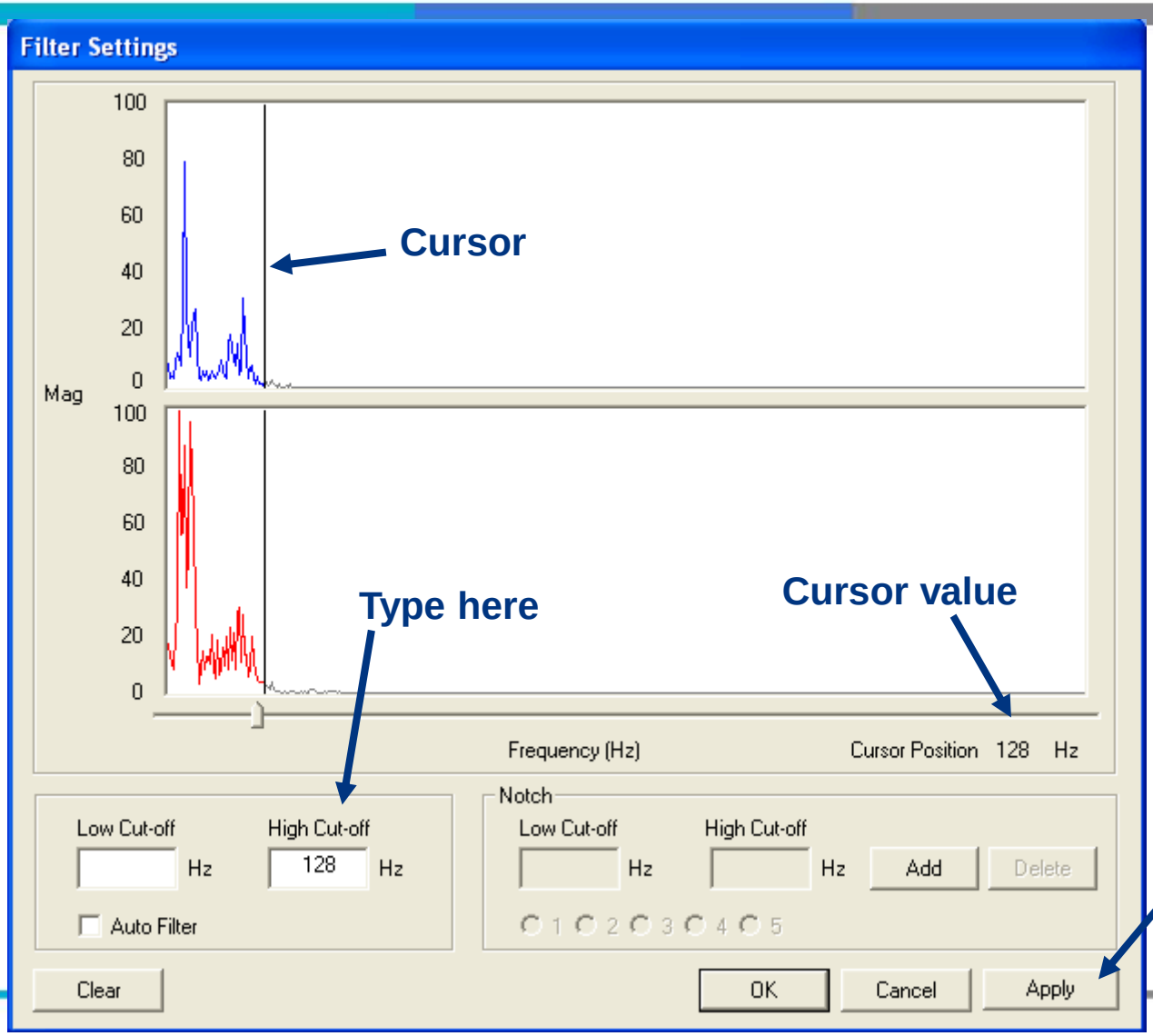
Move cursor to view cut off position

Type in low cut off value

Click “Apply”

High Cut Off

Halma Water Management



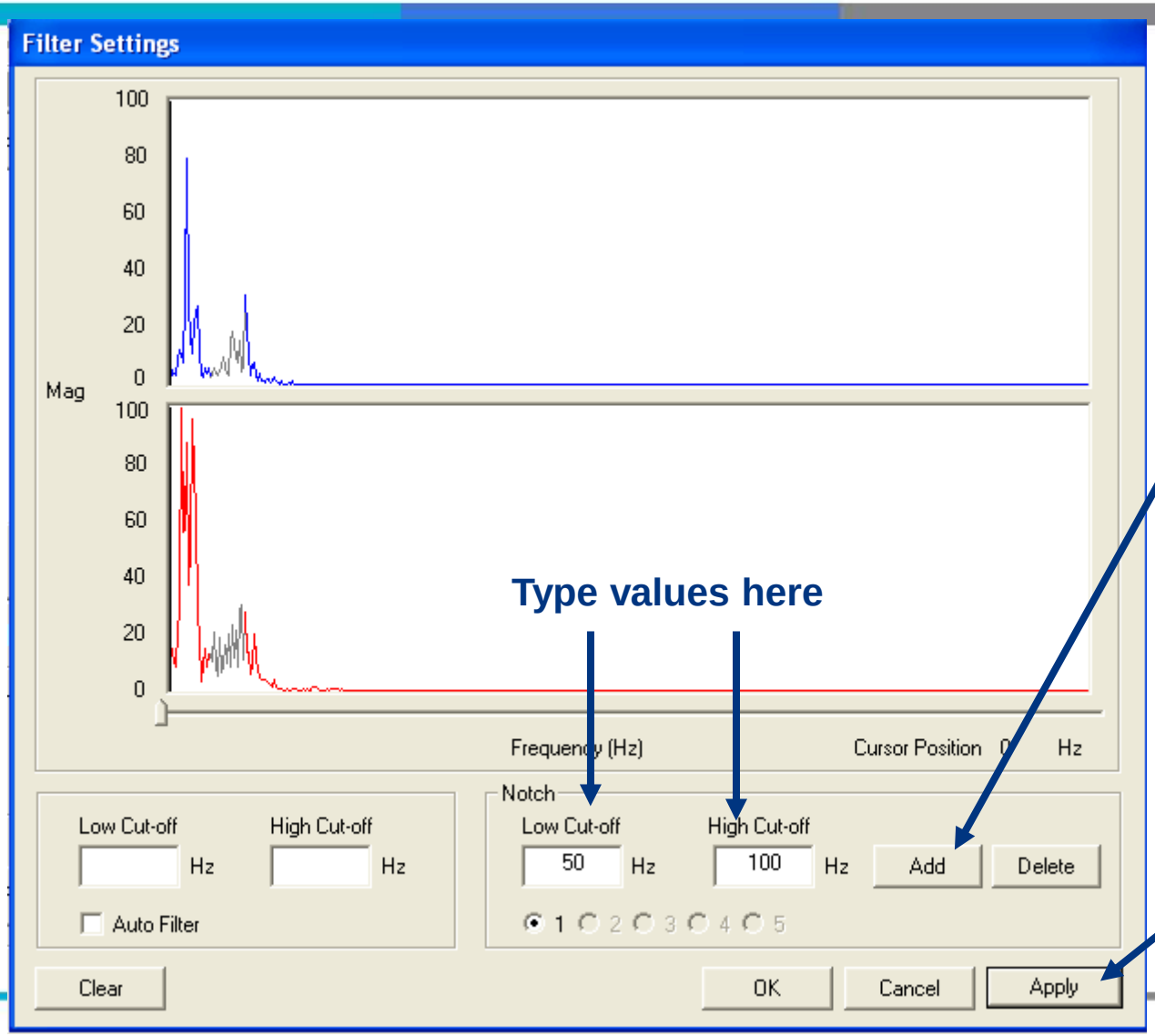
A high cut off is shown set at 128Hz

Move cursor to view cut off position

Type in high cut off value

Click “Apply”

Notch Filter



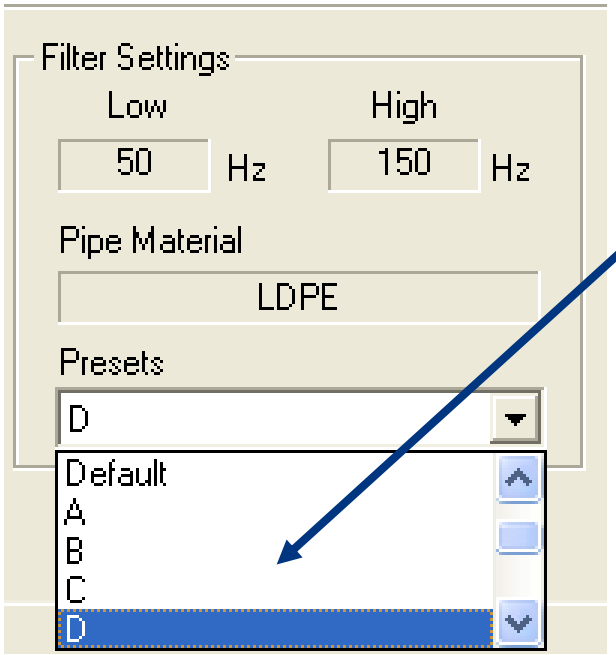
A notch filter is shown set between 50Hz & 100Hz

Click "Add"

Type in low and high cut off values for the notch

Click "Apply"

To Change Filters



When selecting a plastic pipe, options A to J appear under the “Pre-sets” heading.

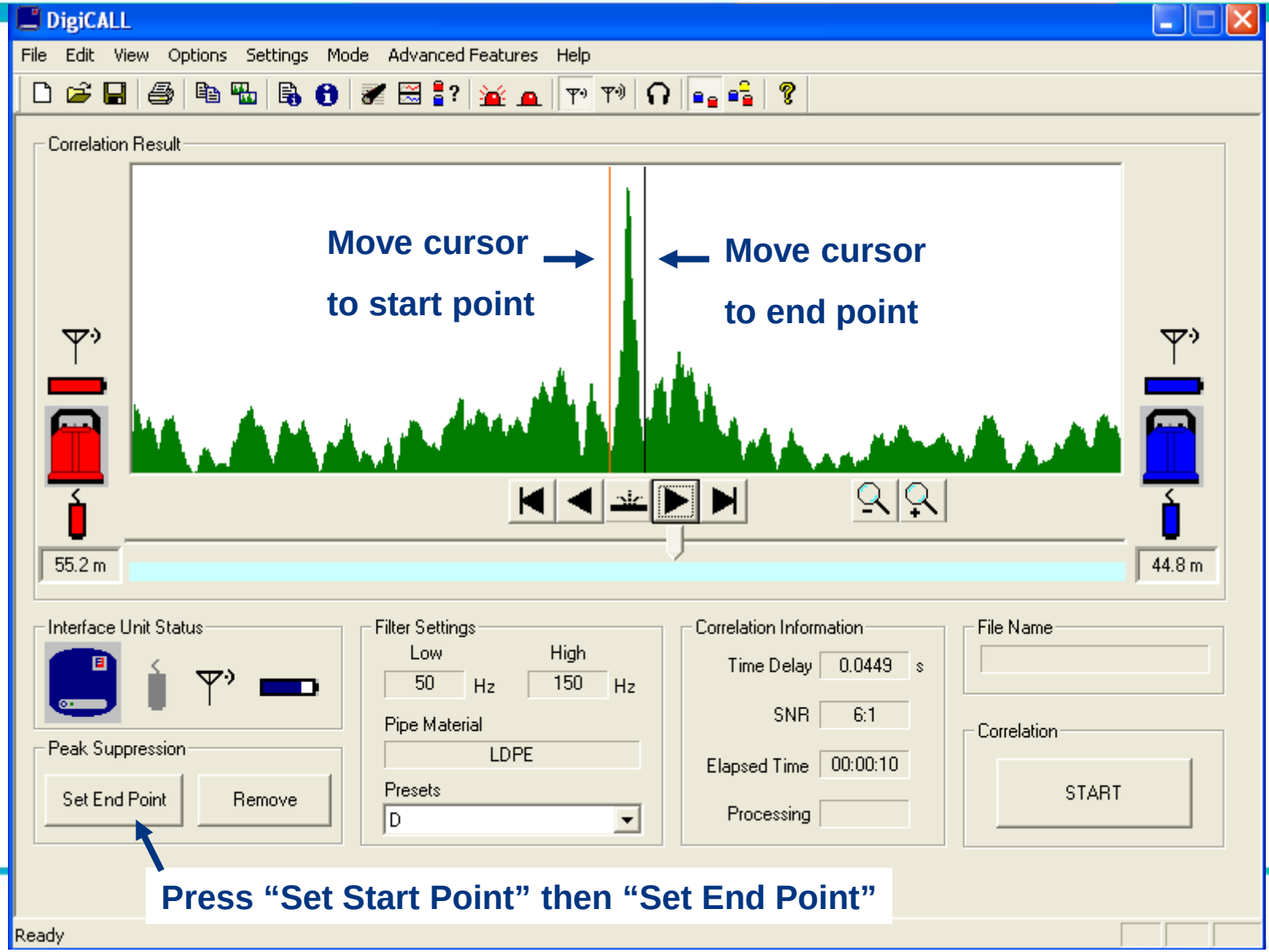
Use the down arrow key to quickly scroll through varying low frequency pre-set plastic filter settings.

This option is only on plastic pipes

Halma Water Management

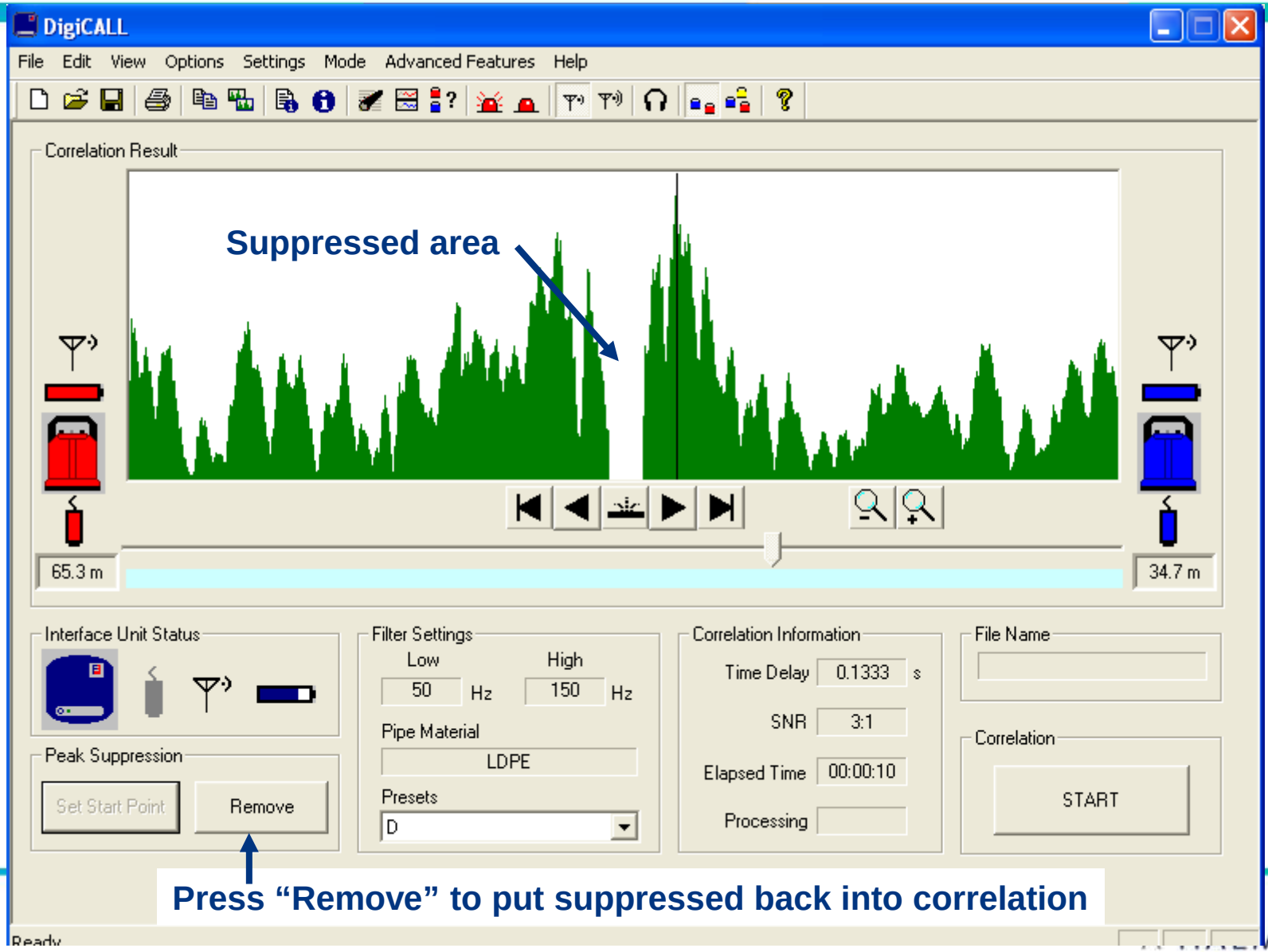
Peak Suppression

Peak Suppression



Peak Suppression

Halma Water Management



Halma Water Management

Calculating Velocity

Why do a Velocity Check ?

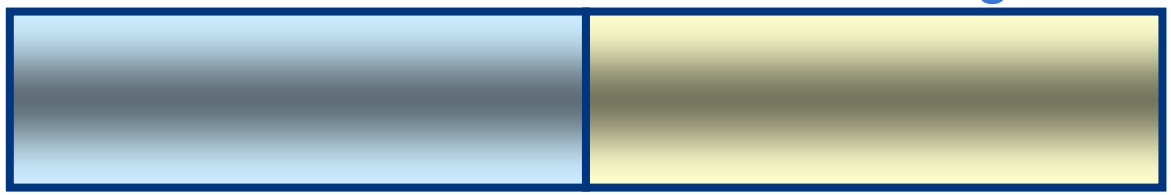
Halma Water Management

Problems

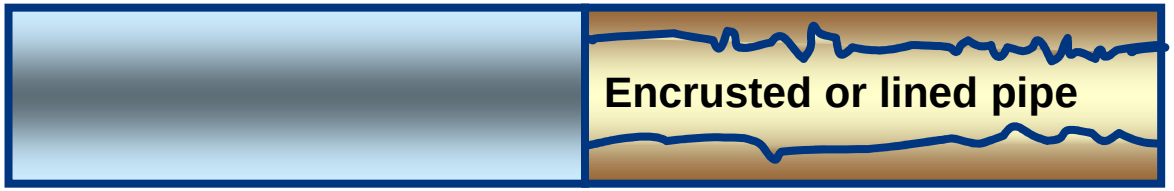
Assumed velocity for each section will be accurate.

Ideal pipework

Overall result good



Problem pipework



Assumed velocity for iron section may be inaccurate.

Velocity of iron section may be difficult to measure.

Overall result may be poor.

Velocity Formula

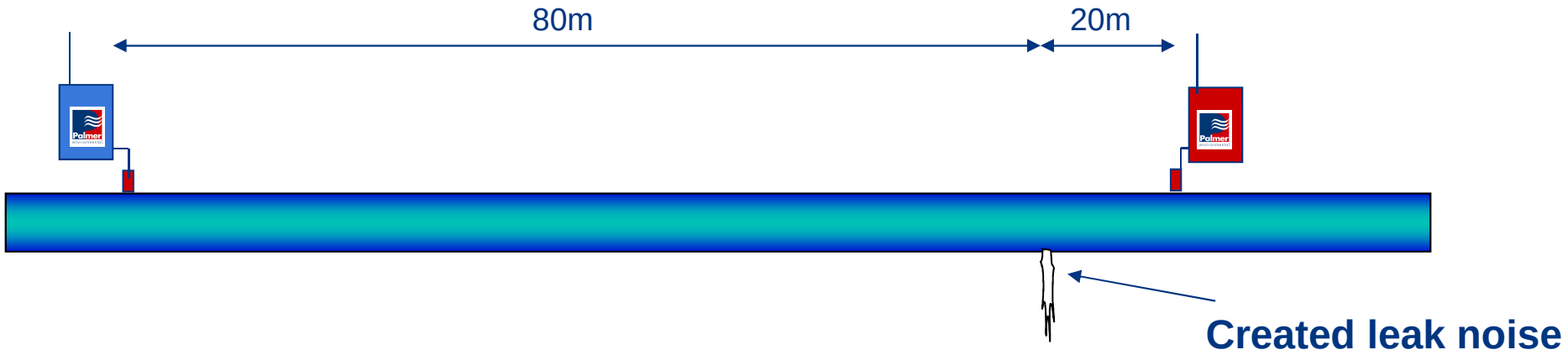
Halma Water Management

$$V = \frac{D - 2L \text{ m/ms}}{Td}$$

L = Leak position (m) **V = Velocity of sound along pipe (m/ms)**

D = Length of pipe (m) **Td = time delay (ms)**

Calculating In Bracket



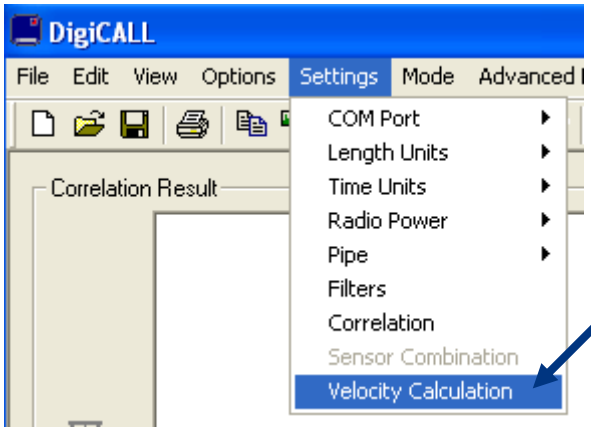
Create a leak between sensors

Start Correlation (using usual data input)

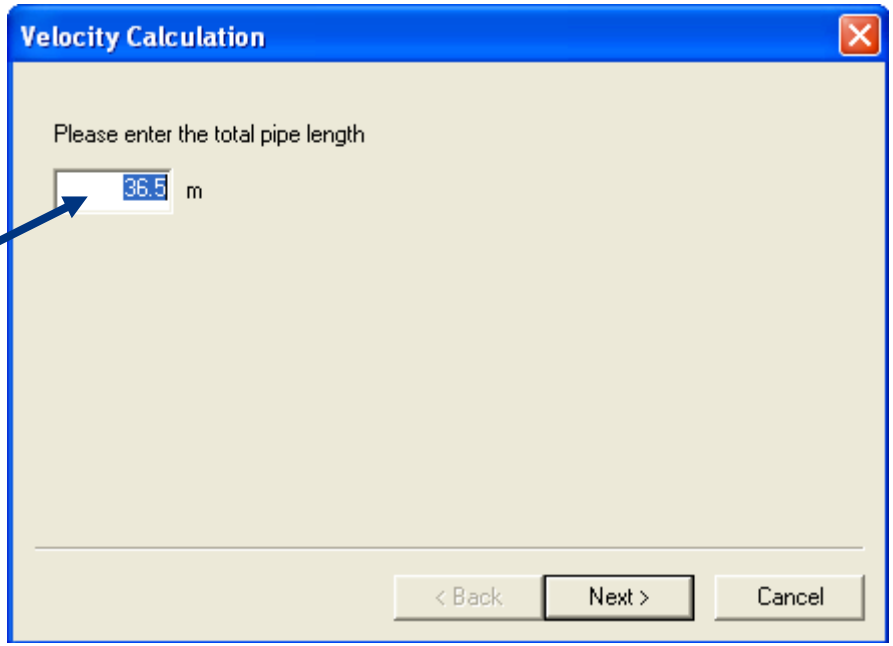
Stop Correlation

Remember : More accurate velocity is calculated when the leak created is closer to one of the sensors over a reasonable length

Calculating In Bracket

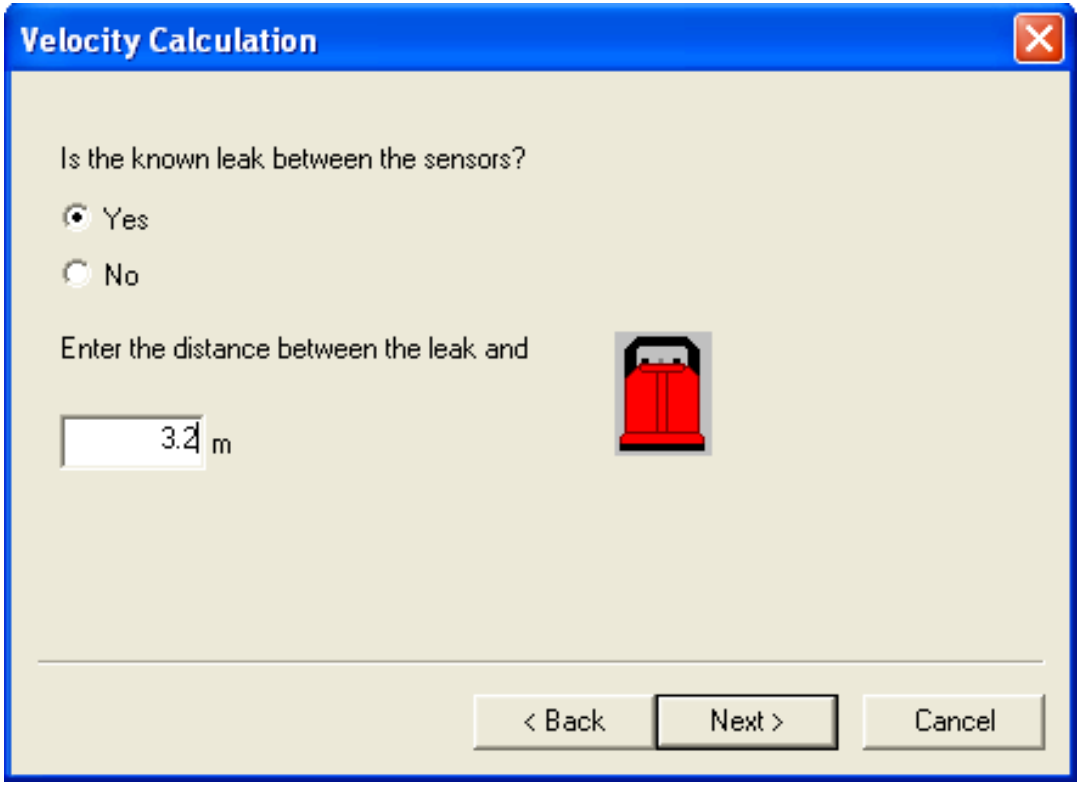


Select “Velocity Calculation”



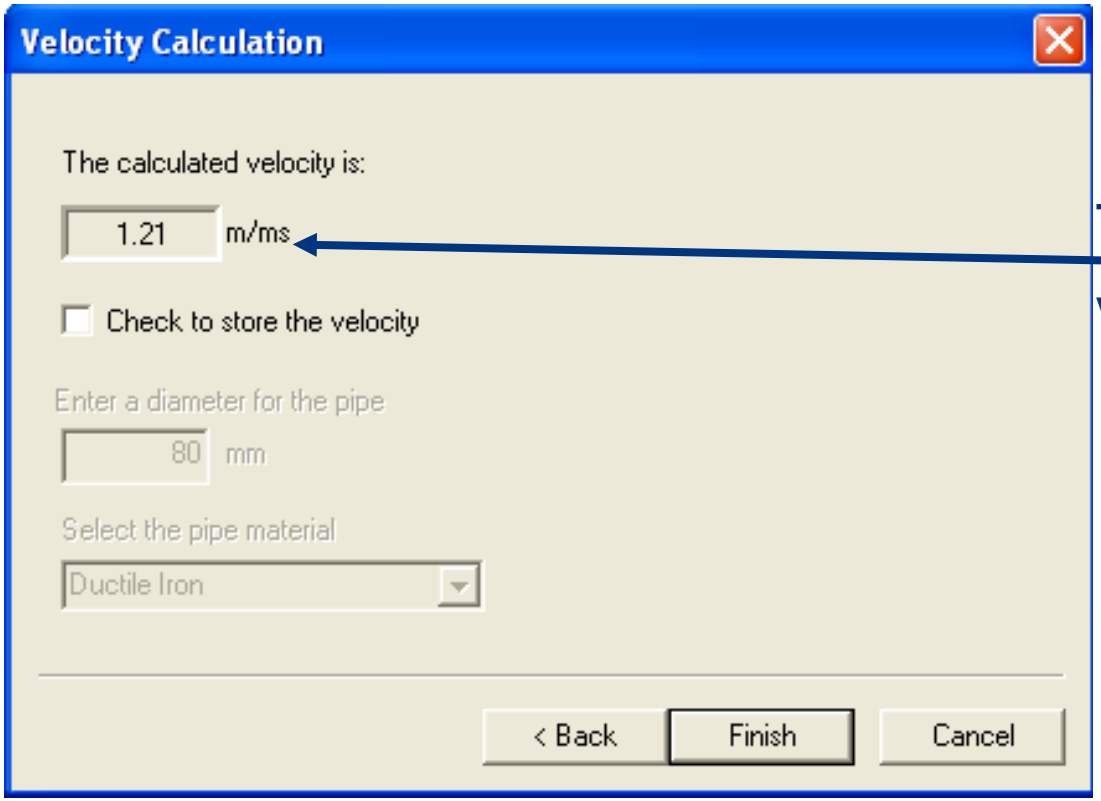
Enter pipe length between sensors and click “Next”

Calculating In Bracket



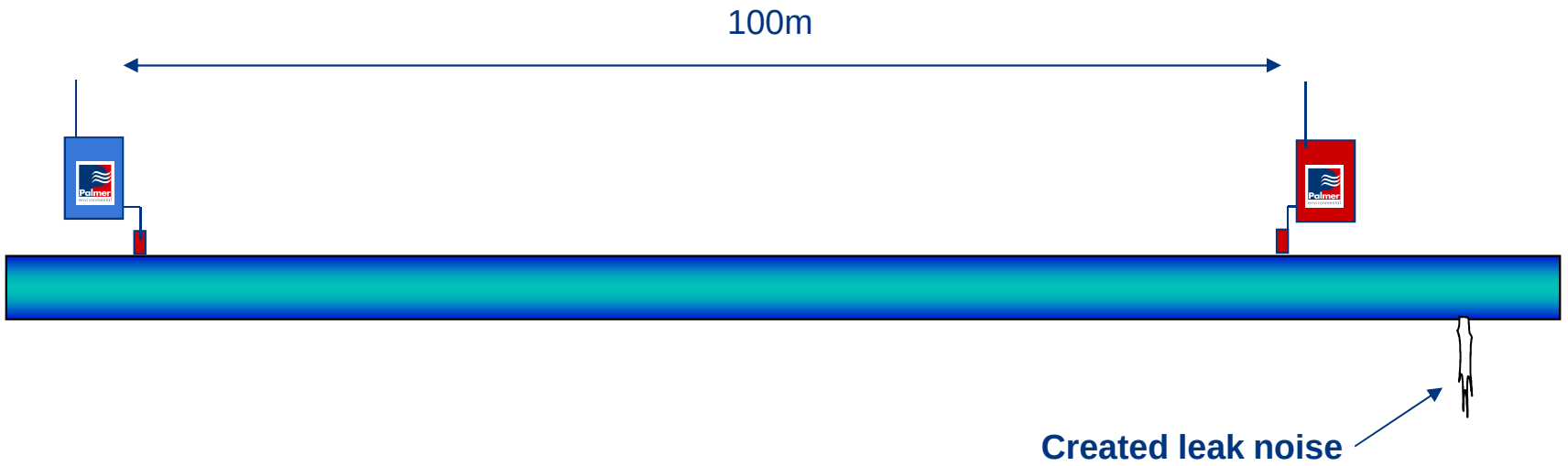
Select “Yes” and enter the distance of the leak from the Red sensor and click “Next”

Calculating In Bracket



The calculated velocity is displayed

Calculating Out Bracket



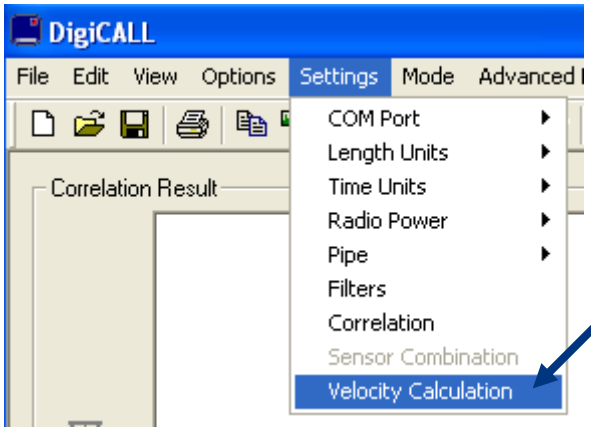
Create leak outside of either sensor

Start Correlation (using usual data input)

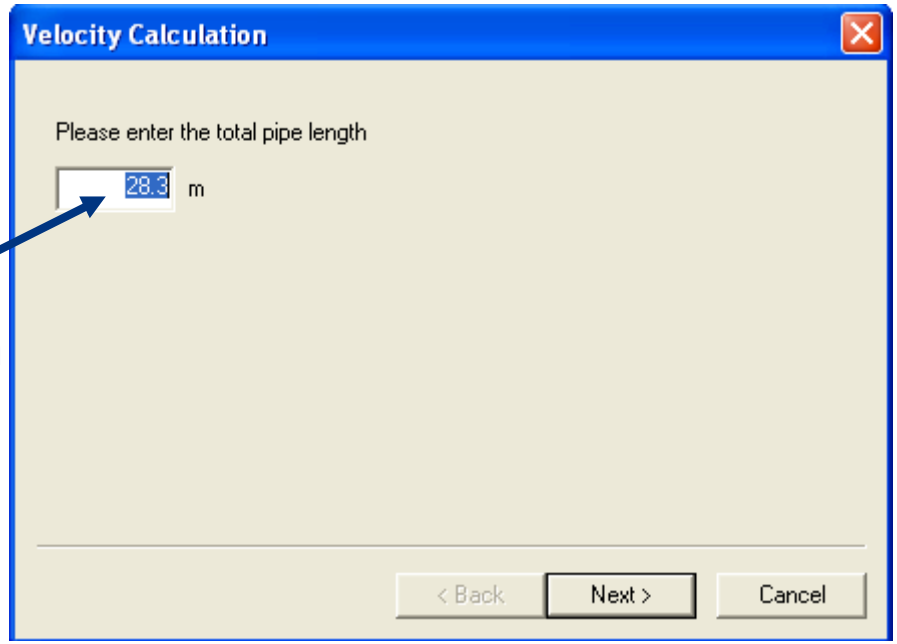
Stop Correlation

Calculating Out Bracket

Halma Water Management

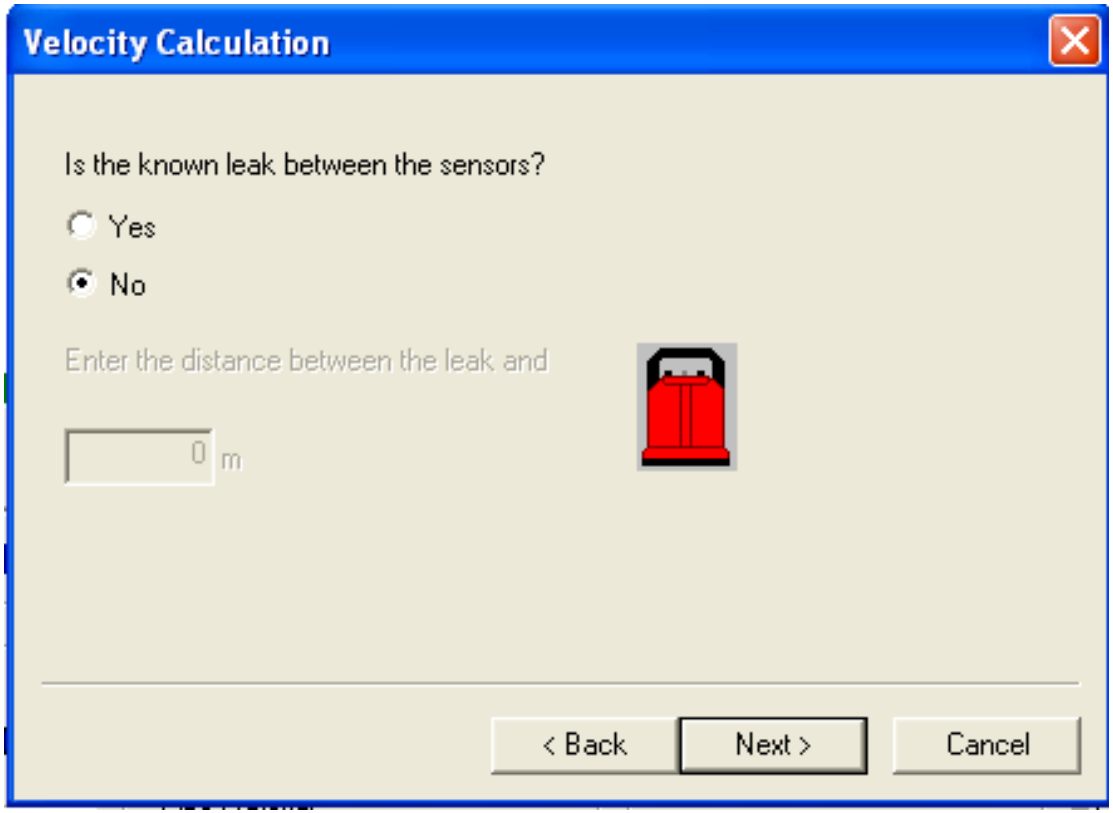


Select “Velocity Calculation”



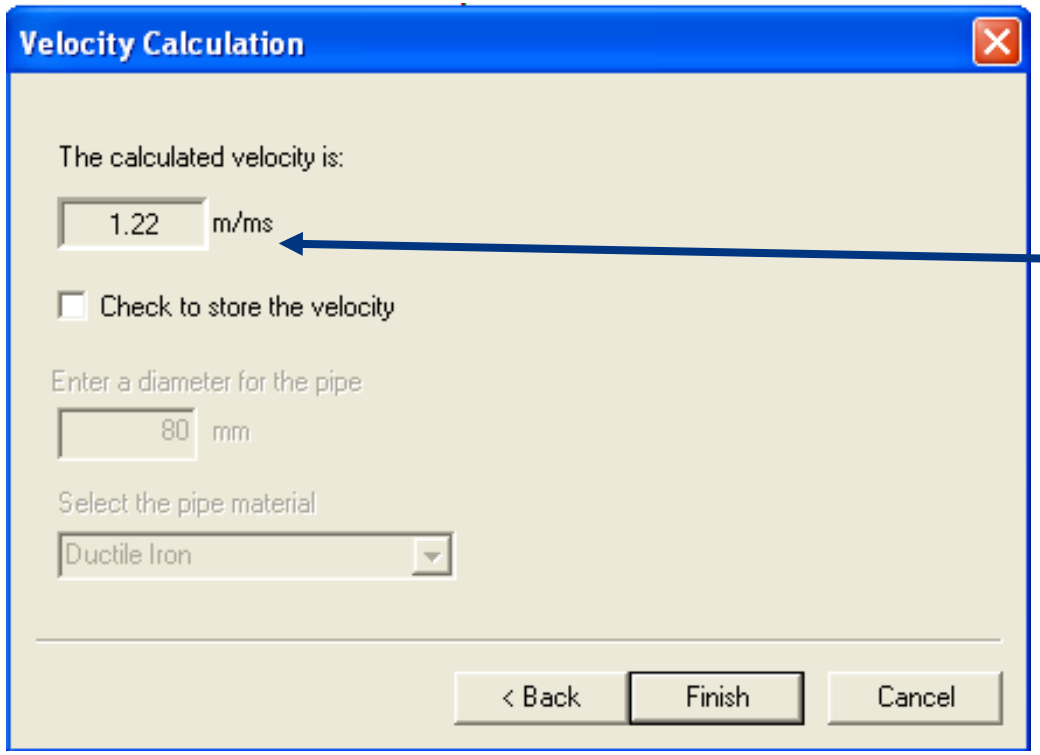
Enter pipe length between sensors and click “Next”

Calculating Out Bracket



Select “No” and click “Next”

Calculating Out Bracket



The calculated velocity is displayed

Velocity Results

Halma Water Management

If velocity results fall into the figures below they can give an indication of material type :-

Iron	**1.35**
Steel	**1.30**
Copper	**1.20**
Lead	**1.10**
Asbestos Cement	**1.10**
PVC	**0.50**
Polythene	**0.20**

Post Processing

Post Processing

Halma Water Management

Providing the correlation was saved, enables the user to changes certain parameters at a later date like :-

Pipe material

Pipe diameter

Distance

Velocity

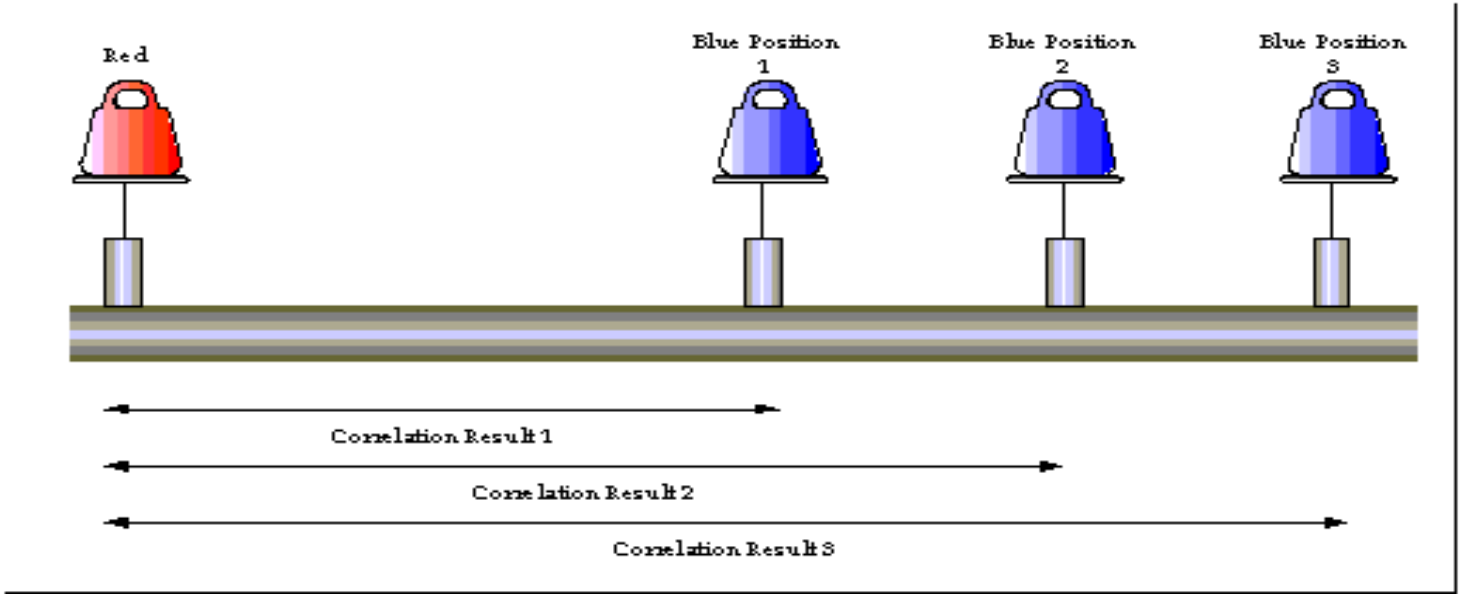
Filters

Halma Water Management

Regression Analysis

Regression Analysis

Halma Water Management



Leave one sensor static and undertake minimum of 3 correlations at different distances, saving each as a separate file.

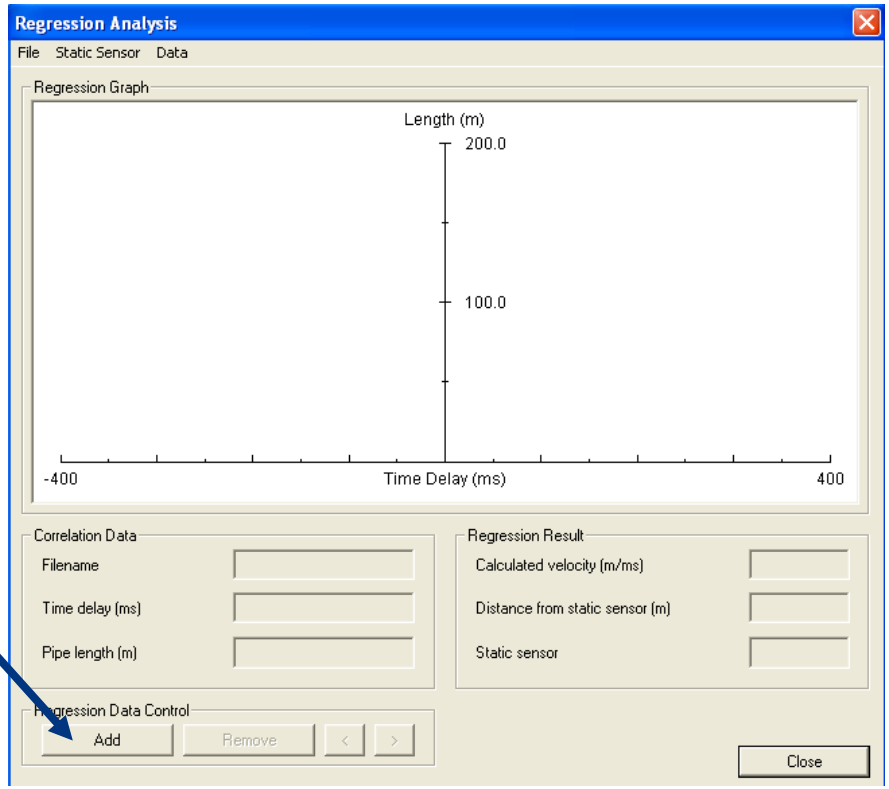
Measures time delay against distance.

Regression Analysis

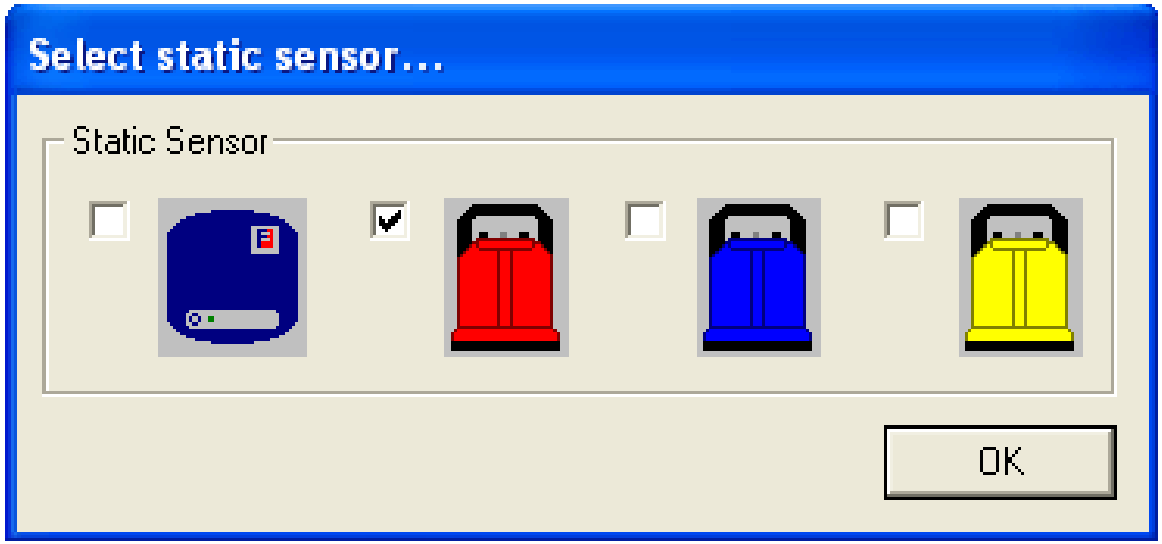
Halma Water Management

Select “Regression Analysis”

Select “Add” and select the first correlation previously saved and click “Open”



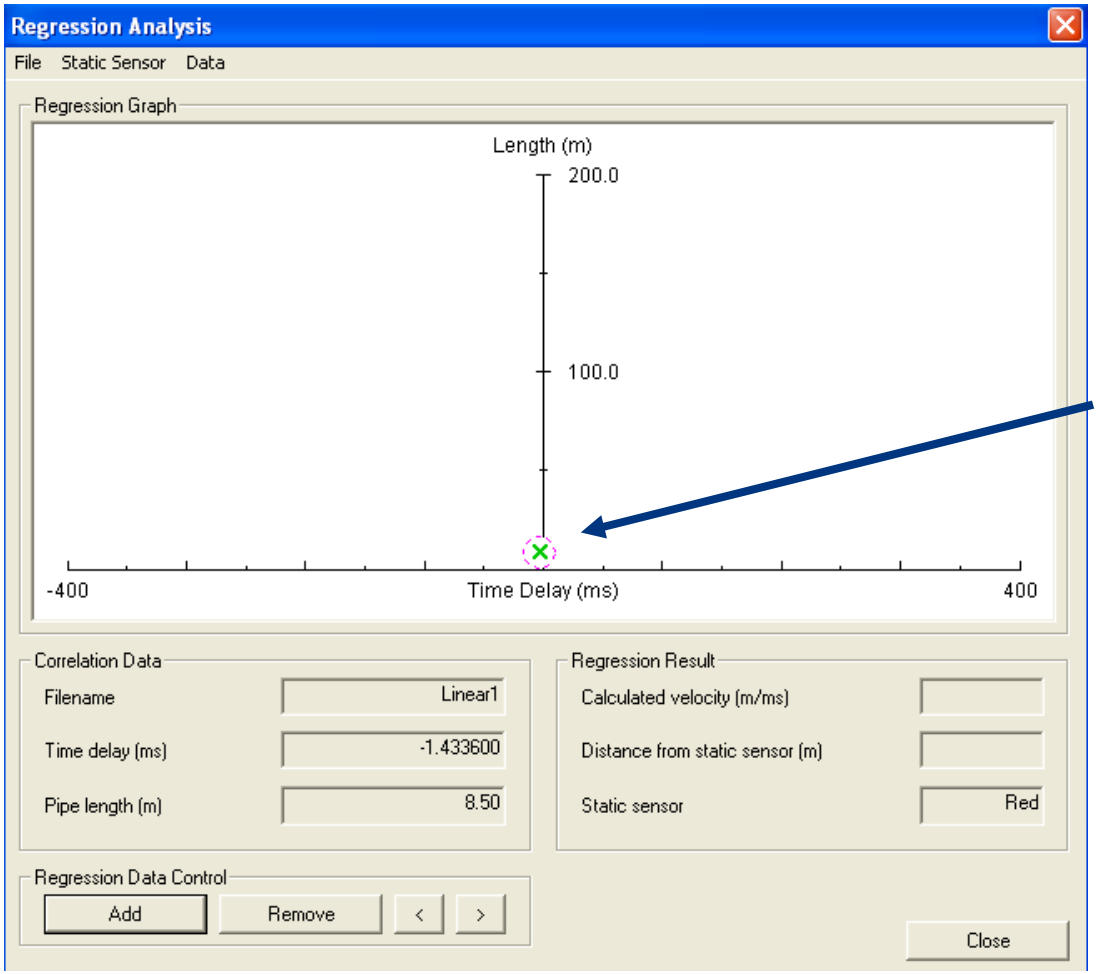
Regression Analysis



Select the static sensor for your test, the one which remained in the same place throughout. Click “Ok”

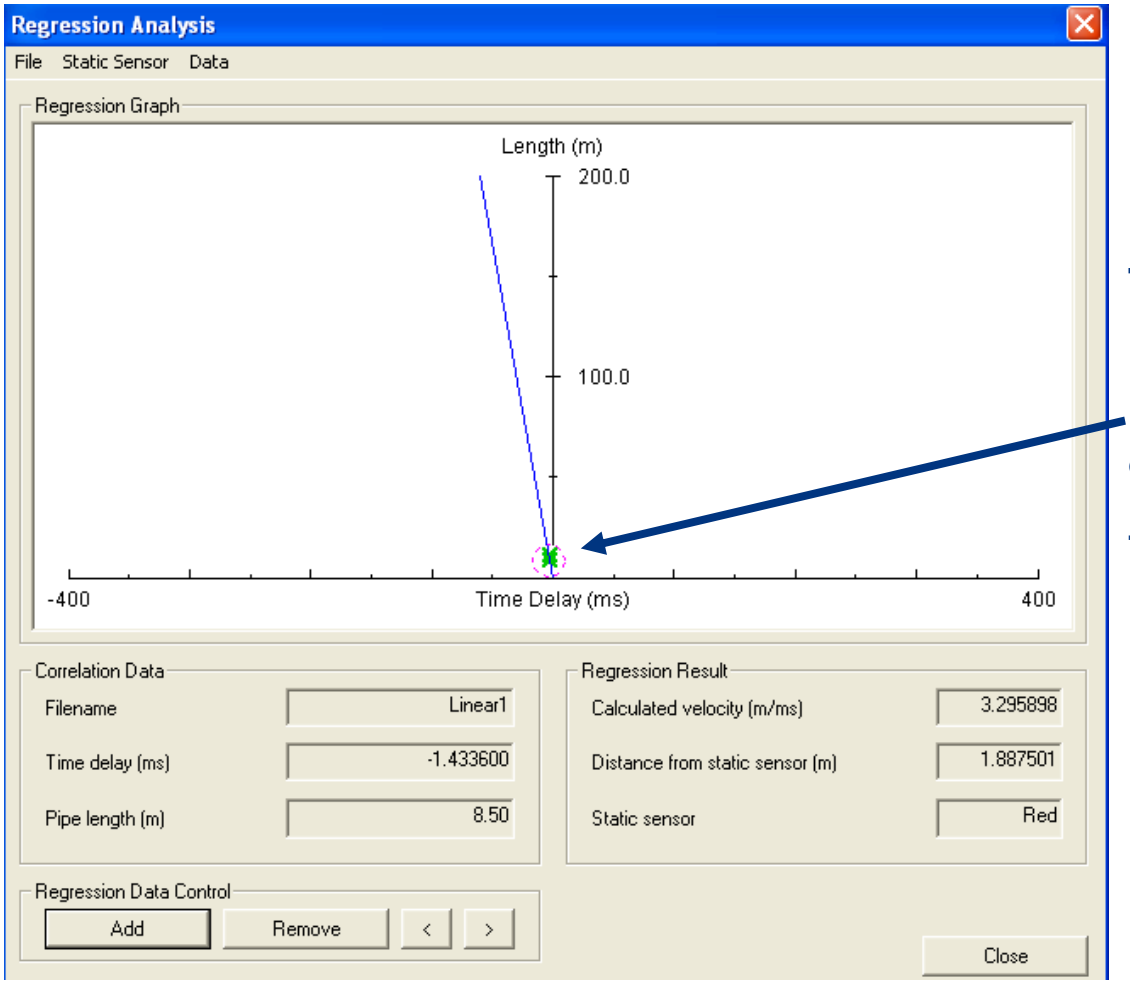
Regression Analysis

Halma Water Management



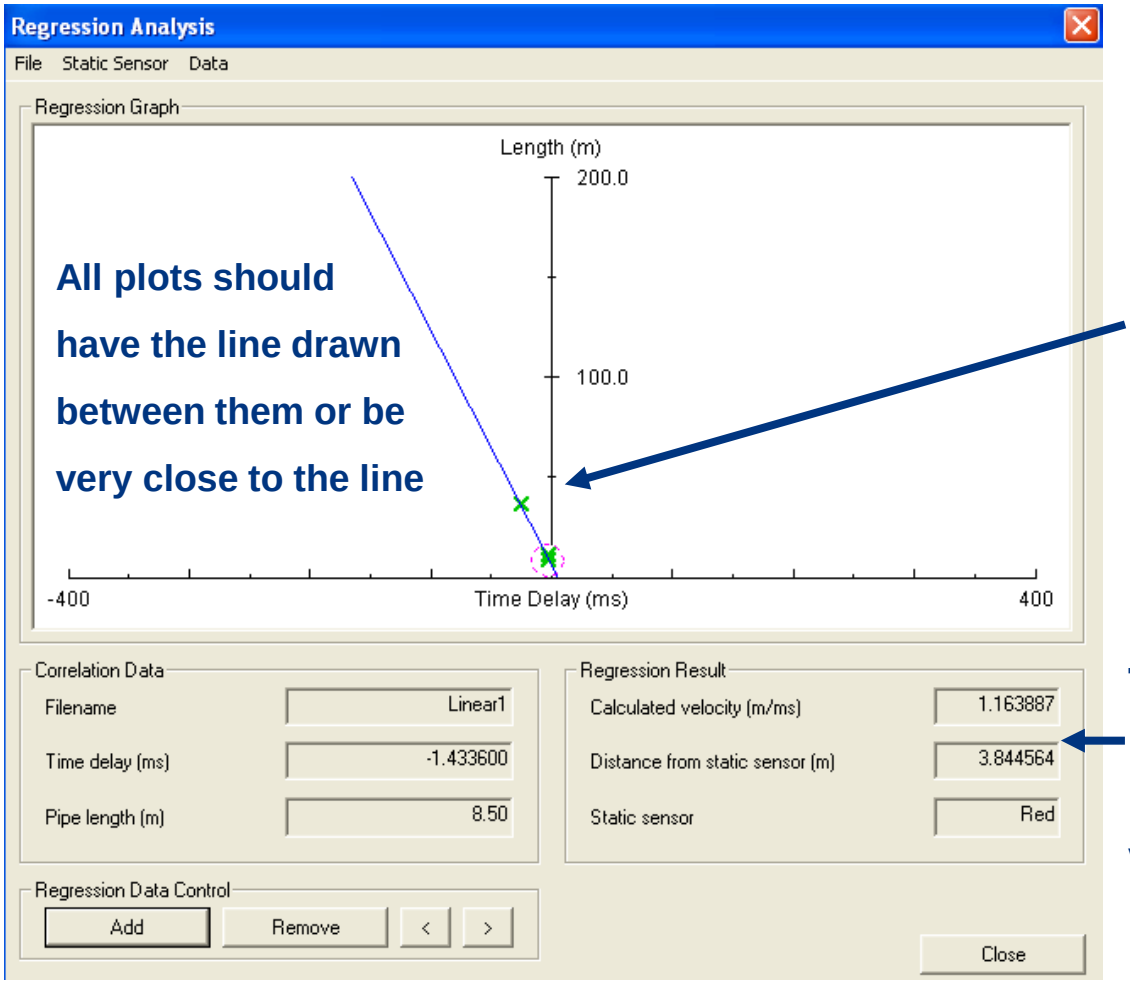
The 1st result is plotted, click “Add” and select the 2nd file saved to be plotted

Regression Analysis



The 2nd result is plotted, click “Add” and select the 3rd file saved to be plotted

Regression Analysis



All plots should have the line drawn between them or be very close to the line

The 3rd result is plotted

The end correlation result and calculated velocity are shown here

Halma Water Management

Three Station Correlation

Three Station Correlation

Halma Water Management

Why use 3 outstations ?

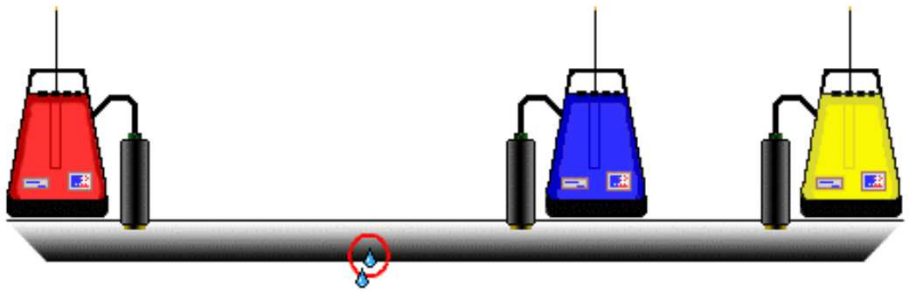
- Obtain 3 correlations in a single site visit
- More correlations = More confident result
- Automatic out of bracket velocity check
- Don’t need to know pipe diameter

Only Rule …….

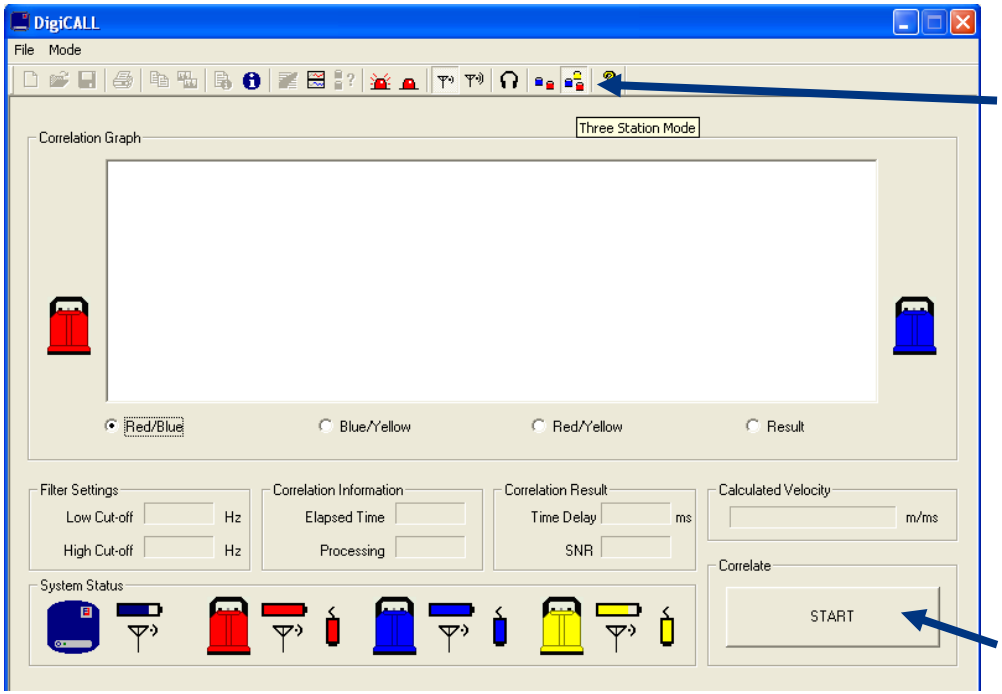
The outstations must be used in the same order every time from left to right, Red, Blue Yellow.

Can’t be used on a “T” section of pipe

Three Station Correlation



Remember to have blue in the middle



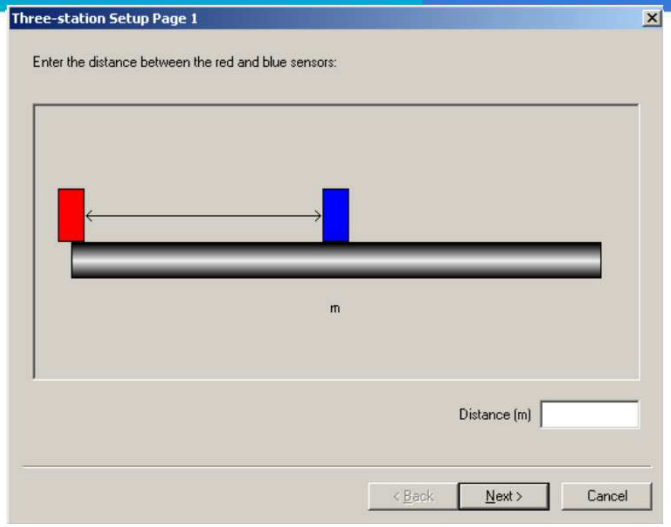
Click on “Three Station Mode”

Slightly different correlation screen appears

Click “Start”

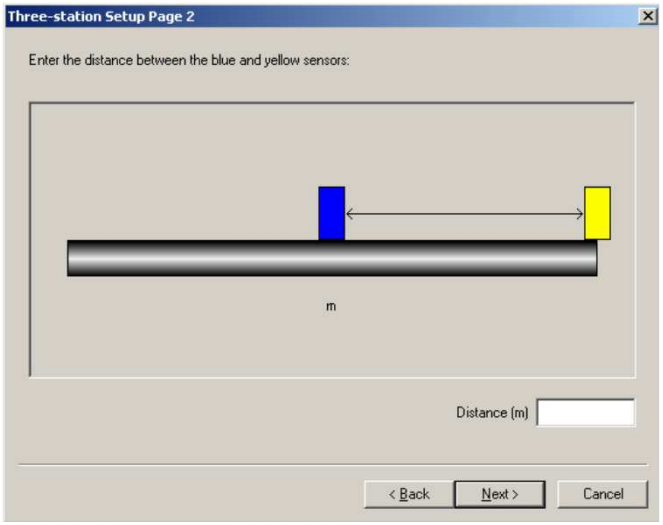
Three Station Correlation

Halma Water Management



Prompts for distance between

red and blue, enter and click “Next”

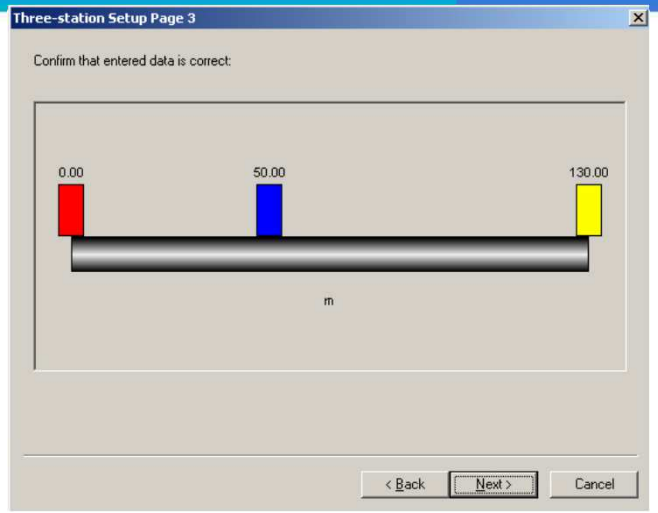


Prompts for distance between

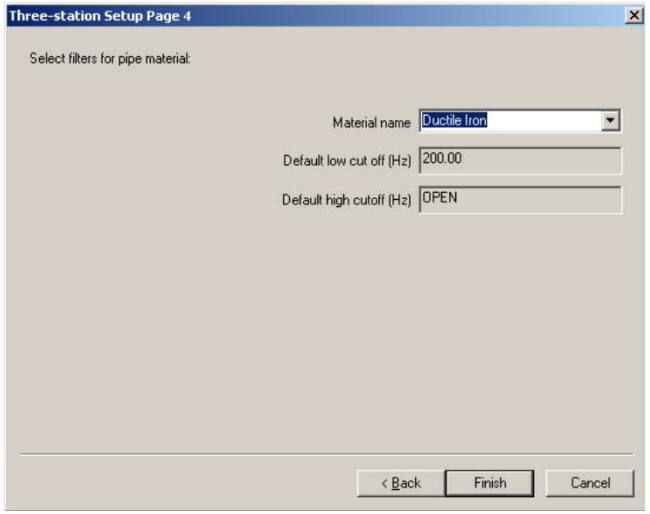
blue and yellow, enter and click “Next”

Three Station Correlation

Halma Water Management



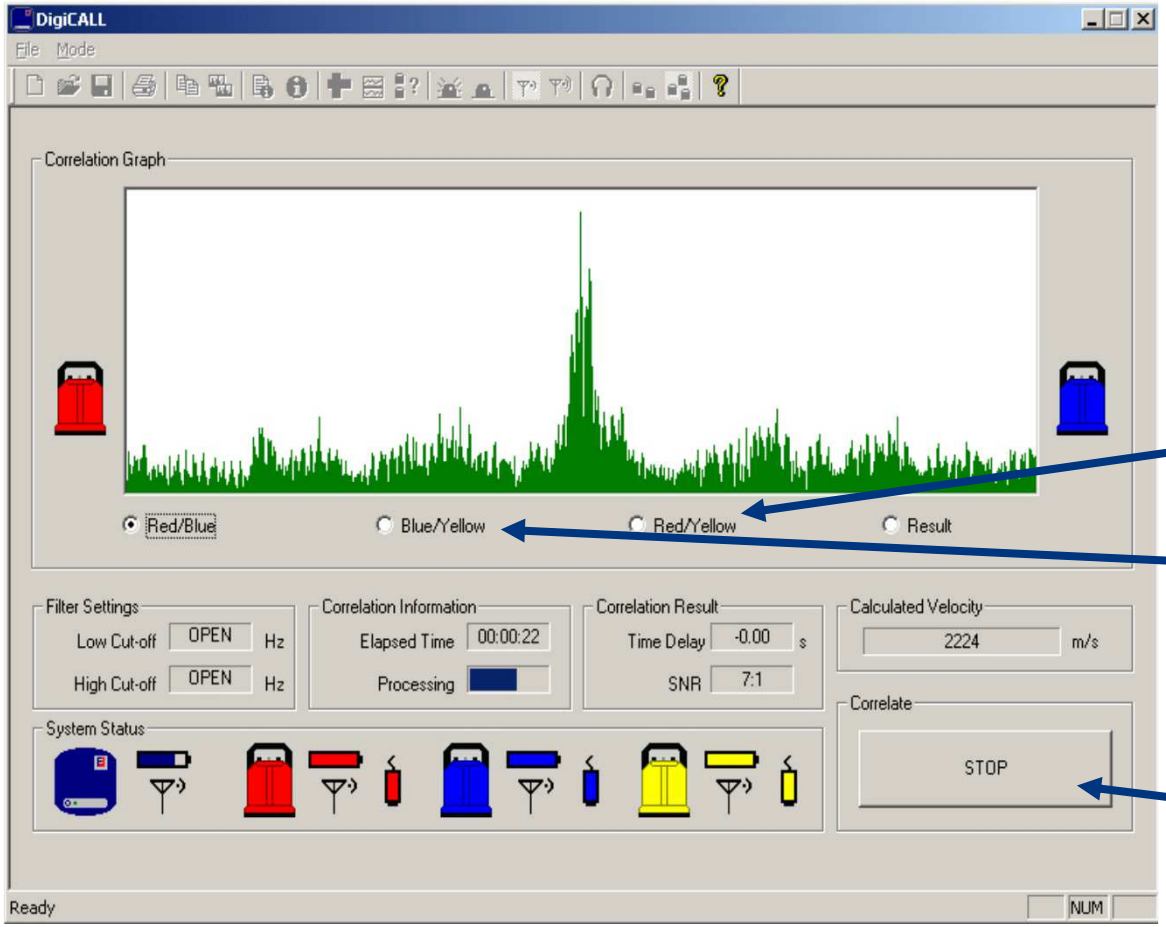
Shows a summary of distances, click “Next”



Enter the material name for the chosen filter range to use, click “Finish” and correlation will begin

Three Station Correlation

Halma Water Management

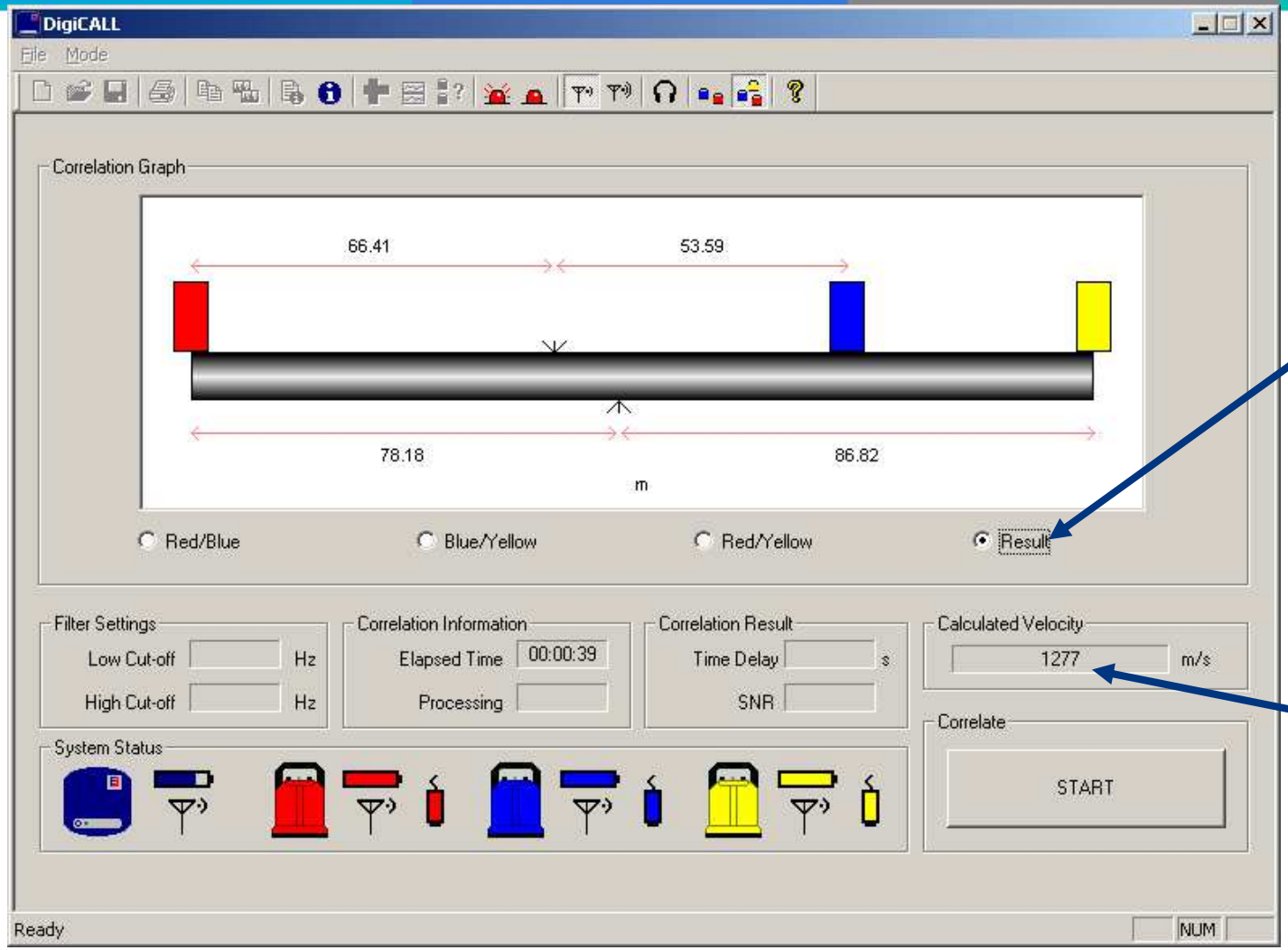


Correlations will appear, to view click on the different sensor combinations.

Once a good peak has established on all click "Stop"

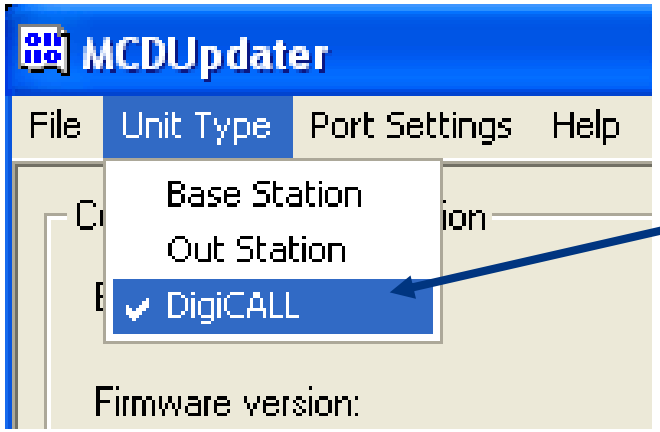
Three Station Correlation

Halma Water Management

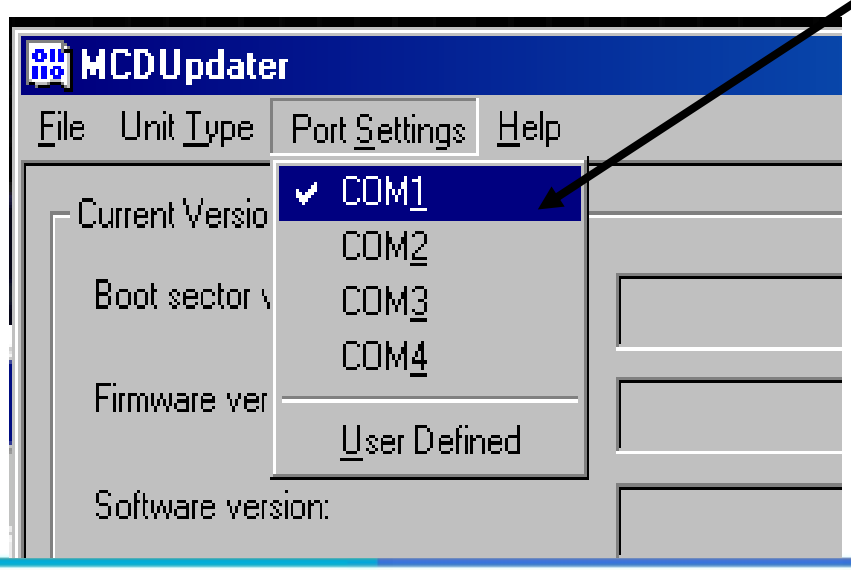


Click "Result" to view leak positions

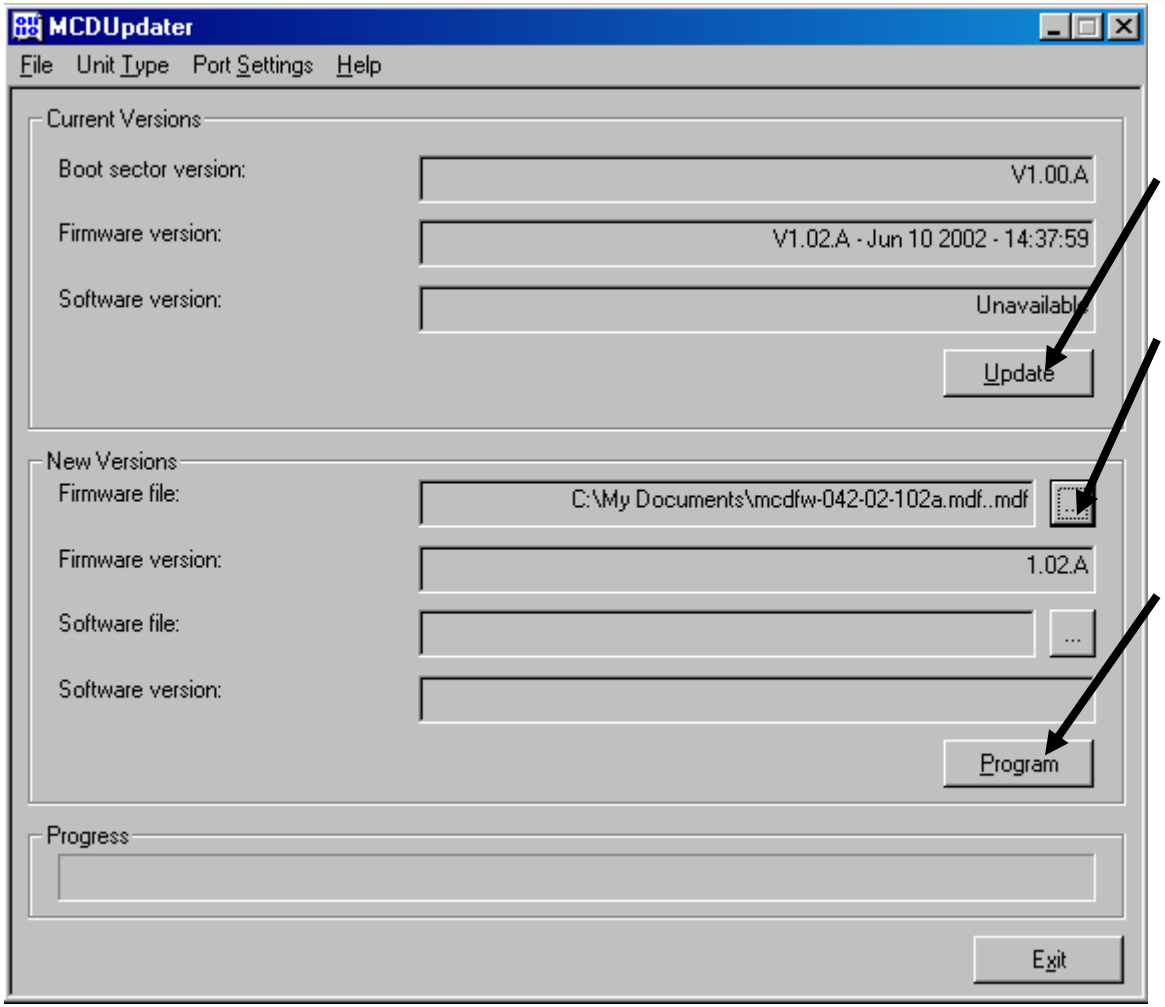
Calculated velocity



Select DigiCALL for interface unit



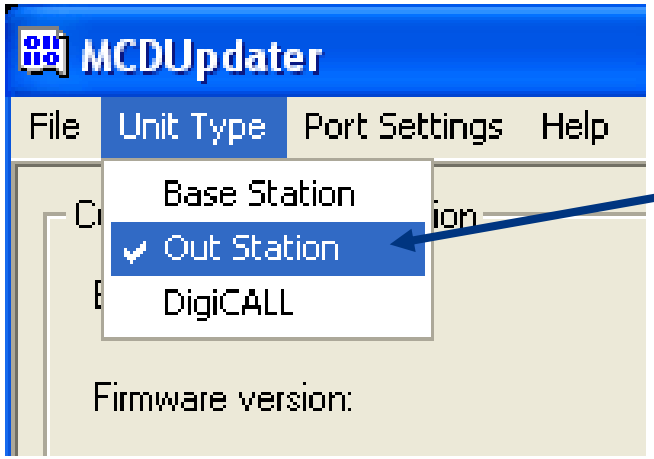
Select correct Comm Port

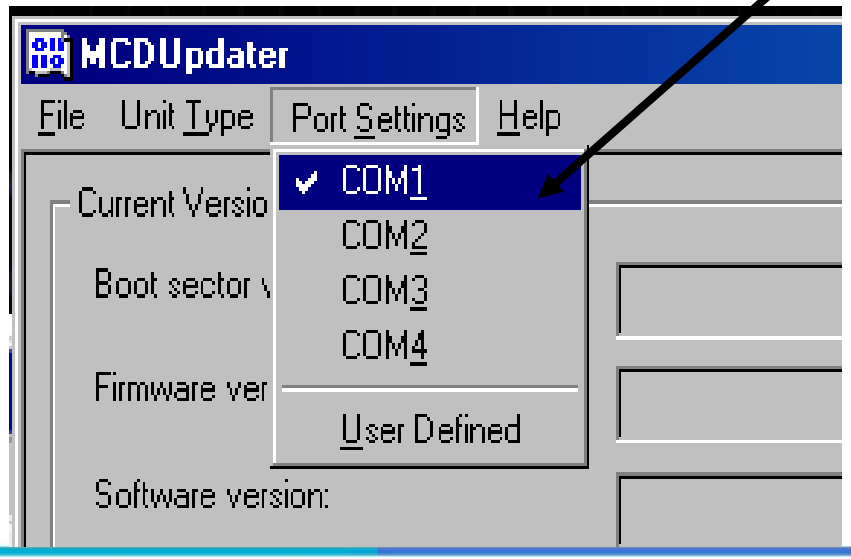


Select Update for current version

Browse for new firmware version and select file (from web site)

Select Program

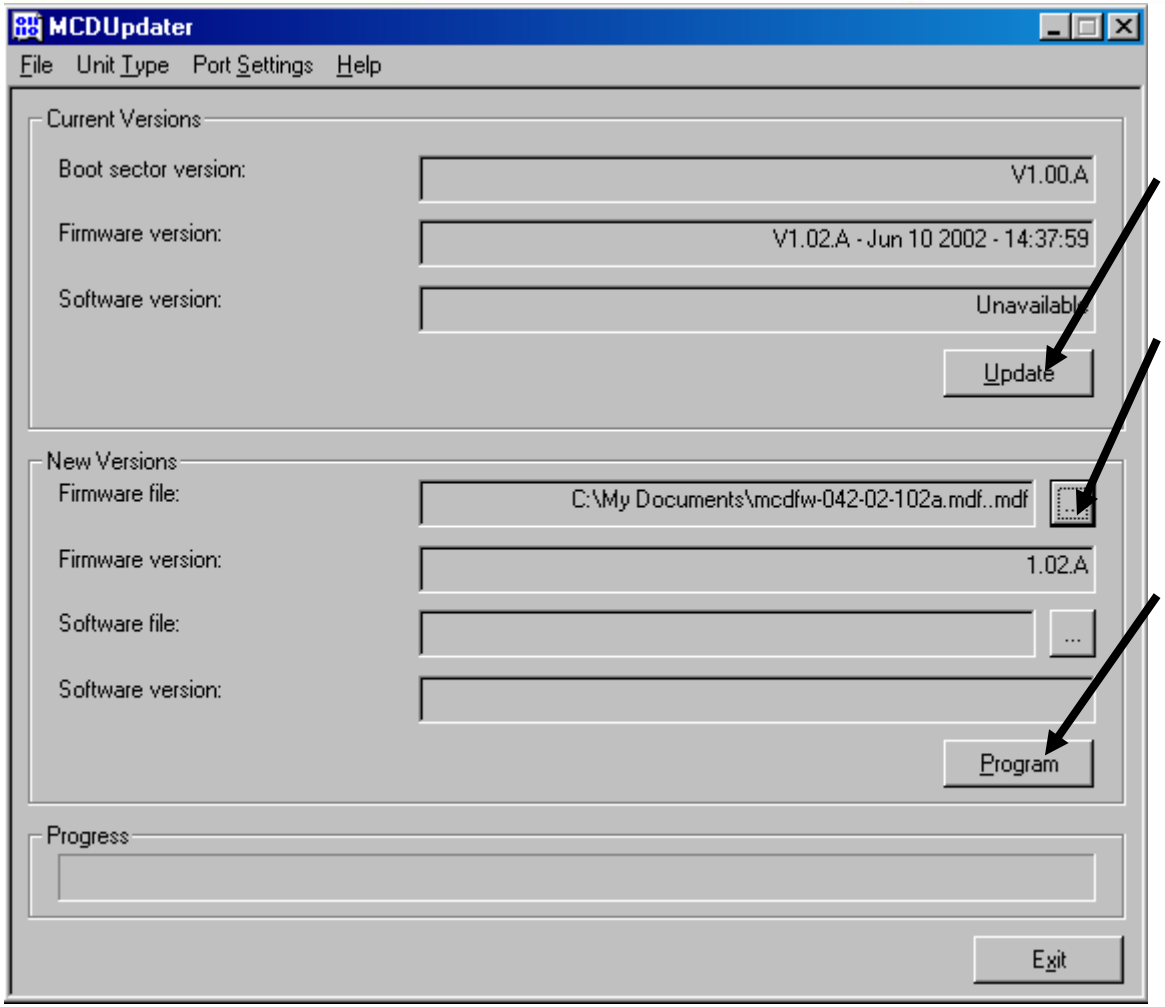




Select Out Station

Select correct Comm Port

Note :- Remember to do both Red & Blue outstations and Yellow where applicable



Select Update for current version

Browse for new firmware version and select file (from web site)

Select Program

Sources of Error

Halma Water Management

Remember the GOLDEN RULE

Rubbish In = Rubbish Out

The more human error cut out the better the possibility of a good result

Sources of Error

Halma Water Management

- **Poor Measurement**
- **Wrong Material**
- **Wrong Pipe Diameter**
- **Parallel Mains (Correlating Different Mains)**
- **Mixed Materials**
- **Tee Connections**
- **Poor Sensor Contact**

Sources of Error

Halma Water Management

A correlator is not a "Magic Box" that will find every leak, noise must be detected at both sensors for a correlation to be good.

That's science !!

Tip……..

Never dig on a correlation peak until confirming with ground sounding.